

# PUBLIC SAFETY RADIO COMMUNICATIONS SYSTEM ASSESSMENT REPORT

Madison County, Virginia

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PREPARED FOR

Madison County, Virginia

14 FEBRUARY 2018



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**Notice:**

This document contains information regarding access to public safety and critical infrastructure telecommunications systems. As such, it may contain and reveal details regarding the location, use, capabilities, limitations, and vulnerabilities of these systems.

Disclosure and dissemination of this information should be limited to those parties engaged in operating, maintaining, or improving the subject systems.

No information regarding the locations, system configurations, frequency usage, subscriber units, access methods, operational plans, drawings, diagrams, or documentation related to their use should be disclosed.

# 1 EXECUTIVE SUMMARY

## 1.1 PURPOSE OF THE PROJECT

Madison County contracted with Black & Veatch to assess the existing radio communications system and make recommendations for improvements to meet the goals of the County.

The County has identified concerns with several aspects of the current VHF voice radio systems. Black & Veatch has submitted a list of questions to the County, conducted site visits, and analyzed the information received from the County and other sources. This document provides an assessment of the County's current VHF voice communications systems. The information in this document will form the basis for identifying the next steps in upgrading the County's voice communications systems. The goal of the project is to provide reliable and enhanced radio communications to Madison County public safety and governmental users.

## 1.2 PROJECT WORK PLAN

The scope of services for this project is divided into the following phases and tasks:

1. Phase I – Needs Assessment and Recommendations
  - a. Task One: Project Kick-off Meeting and Schedule
  - b. Task Two: Current Infrastructure and Needs Assessment
  - c. Task Three: Frequency Band Analysis
  - d. Task Four: RF Coverage Analysis
  - e. Task Five: System Enhancement Recommendations Report & Presentation

This draft report, documents the efforts and findings of Phase I, Tasks One through Task Five.

## 1.3 SUMMARY OF FINDINGS

During the review of the responses to the survey questionnaire and interviews, the following issues have been revealed:

1. Radio Coverage Issues:
  - a. Poor radio coverage is experienced by both Mobile and Portable radios.
  - b. Having to decide which site to use.
  - c. The reported areas of poor coverage are:
    - South Seminole Trail between South Main St. and the 1700 Block (transmit),
    - Many areas with terrain issues (both transmit and receive),
    - Extreme south end of the county (transmit)
    - Extreme western side of the county (transmit and receive).
2. Channel Congestion:
  - a. When users trying to talk at the same time.
  - b. During large scale incidents, and severe weather.

3. Interoperability:
  - a. Interoperability with neighboring jurisdictions.

## 1.4 SUMMARY OF ALTERNATIVES

Black & Veatch has constructed the following options and alternatives, all P25 trunked and in VHF frequency band. These alternatives and options are evaluated; each alternative is presented along with a discussion of its advantages and disadvantages. The analysis then concludes a long-term path for the Madison County.

The following potential enhancement options for the voice communications systems are considered:

1. Madison County to procure and implement a stand-alone system:  
In this option, Madison county implements its own stand-alone system, a 3-site, 4-channel simulcast system with a P25 core switch owned by Madison County. It includes constructing one new tower and using two of the existing tower sites.
2. Madison and Greene Counties to implement a shared system.  
In this option, Madison and Greene counties implement a shared system. The shared options are as follows:
  - a. Madison County and Green County implement their own RF simulcast sites, each a 3-site, 4-channel, system, and share a common core switch.
  - b. Madison County and Green County implement a common 6-site, 7-channel RF simulcast system, with 3 sites, in each county, and share a common core switch.
3. Madison and/or Greene Counties to implement a shared, regional system with Fluvanna and Louisa Counties.
  - a. In this option, Madison and Greene counties implement their own RF simulcast sites, each a 3-site system, and share the existing core switch utilized by Fluvanna and Louisa Counties. The coverage and system capacity is the same as alternative 2a.
  - b. Or Madison County and Green implement a common 6-site RF simulcast system, with 3-sites in each county, and share the existing core switch utilized by Fluvanna and Louisa Counties. The coverage and system capacity is the same as alternative 2b.

## 1.5 COMPARISON OF ALTERNATIVES

An estimate of capital cost and reoccurring annual maintenance cost is provided in Table 1 below:

Table 1: Cost Comparison of Alternatives

DESCRIPTION	ALTERNATIVE 1:	ALTERNATIVE 2:	ALTERNATIVE 3:
	Madison County Stand-Alone System	Madison and Greene County Shared System	Regional System (Madison, Greene, Louisa, Fluvanna)
System Infrastructure	\$5,026,000	\$4,475,000	\$4,150,000
Subscribers	\$862,000	\$862,000	\$862,000
<b>Madison County Estimated Cost</b>	<b>\$5,888,000</b>	<b>\$5,337,000</b>	<b>\$5,012,000</b>
Recurring Costs			
System Maintenance / Year	\$220,000	\$220,000	\$220,000

Black & Veatch conducted an analysis of the alternatives for the County and compared the advantages and disadvantages of each. The advantages of each alternative are listed in Table 2 below:

Table 2: Comparison of Alternative Advantages

ALTERNATIVE 1 ADVANTAGES	ALTERNATIVE 2 ADVANTAGES	ALTERNATIVE 3 ADVANTAGES
<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can be monitored and recorded by Dispatch</li> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the system.</li> </ul>	<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can be monitored and recorded by Dispatch</li> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the RF simulcast system.</li> </ul>	<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can be monitored and recorded by Dispatch</li> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the RF simulcast system.</li> </ul>

ALTERNATIVE 1 ADVANTAGES	ALTERNATIVE 2 ADVANTAGES	ALTERNATIVE 3 ADVANTAGES
<ul style="list-style-type: none"> <li>Extended battery operation when compared to analog radios</li> <li>Alarm and control systems will be in place, which will alert the County when system failures occur. This will facilitate a timely response by the County's maintenance service provider.</li> <li>Availability of P25 Phase 1 pager—P25 Phase 2 is being developed.</li> </ul>	<ul style="list-style-type: none"> <li>Extended battery operation when compared to analog radios</li> <li>Alarm and control systems will be in place, which will alert the County when system failures occur. This will facilitate a timely response by the County's maintenance service provider.</li> <li>Availability of P25 Phase 1 pager—P25 Phase 2 is being developed.</li> <li>Reduced cost of the system due to shared network.</li> <li>Governance and oversight of the shared system</li> </ul>	<ul style="list-style-type: none"> <li>Extended battery operation when compared to analog radios</li> <li>Alarm and control systems will be in place, which will alert the County when system failures occur. This will facilitate a timely response by the County's maintenance service provider.</li> <li>Availability of P25 Phase 1 pager—P25 Phase 2 is being developed.</li> <li>Reduced cost of the system due to shared network.</li> <li>Governance and oversight of the shared system</li> </ul>

The disadvantages for each alternative are listed in Table 3 below:

Table 3: Comparison of Alternative Disadvantages

ALTERNATIVE 1 DISADVANTAGES	ALTERNATIVE 2 DISADVANTAGES	ALTERNATIVE 3 DISADVANTAGES
<ul style="list-style-type: none"> <li>FCC licensing – requires concurrence from co-channel users</li> <li>The digital system is susceptible to co-channel interference</li> <li>County is responsible for capital and recurring cost of the system.</li> <li>Requires new subscriber radios</li> <li>Higher cost subscriber radios</li> <li>Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> </ul>	<ul style="list-style-type: none"> <li>FCC licensing – requires concurrence from co-channel users</li> <li>The digital system is susceptible to co-channel interference</li> <li>County is responsible for capital and recurring cost of RF simulcast system.</li> <li>Requires new subscriber radios</li> <li>Higher cost subscriber radios</li> <li>Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> <li>Governance and oversight of the shared system</li> </ul>	<ul style="list-style-type: none"> <li>FCC licensing – requires concurrence from co-channel users</li> <li>The digital system is susceptible to co-channel interference</li> <li>County is responsible for capital and recurring cost of RF simulcast system.</li> <li>Requires new subscriber radios</li> <li>Higher cost subscriber radios</li> <li>Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> <li>Enhancements to the P25 core switch for applications such as GPS/AVL may require agreements from all parties for cost sharing.</li> <li>Governance and oversight of the shared system</li> </ul>

## 1.6 RECOMMENDATIONS

This report identifies solutions for meeting the needs of the County. The solutions vary from replacing the current system with a standalone P25 system to developing an agreement to operate

on neighboring systems. Each has its benefits and disadvantages as discussed previously in this report.

After careful consideration and analysis of each of the three alternatives, the consultant recommends that Madison County pursue Alternative 2 or 3: Implement a shared system with Greene County and/or share the core switch with Fluvanna/Louisa County 150 MHz Radio System.

## 1.7 NEXT STEPS

The communications solutions will require coordination and consensus of all the entities to help focus on the best overall solution. To identify and successfully implement an effective long-term solution, the following steps are recommended.

- Establish an oversight committee representing public safety communications stakeholders for Madison and Green counties.
- Establish the collective set of requirements for all the entities represented by the stakeholders.
- Begin discussion and evaluation of governance of a shared P25 system.
- Identify funding sources for implementation of the preferred solution.
- Develop a technical specification and statement of work (SOW). The SOW establishes the requirements for the options discussed in this report.
- Request a proposal from Motorola responding to the SOW.
- Evaluate the proposal received.
- Negotiate a contract for the selected option.

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END OF EXECUTIVE SUMMARY

## 2 INTRODUCTION

### 2.1 PURPOSE OF THE PROJECT

Madison County contracted with Black & Veatch to assess the existing radio communications system and make recommendations for improvements to meet the goals of the County.

The County has identified concerns with several aspects of the current VHF voice radio systems. Black & Veatch has submitted a list of questions to the County, conducted site visits, and analyzed the information received from the County and other sources. This document provides an assessment of the County's current VHF voice communications systems. The information in this document will form the basis for identifying the next steps in upgrading the County's voice communications systems. The goal of the project is to provide reliable and enhanced radio communications to Madison County public safety and governmental users.

### 2.2 PROJECT WORK PLAN

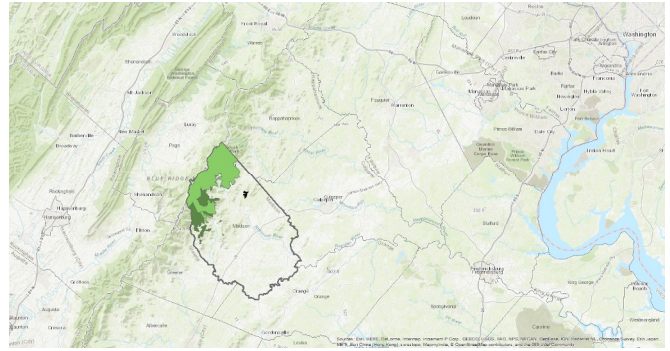
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  - d. Task Four: RF Coverage Analysis
  - e. Task Five: System Enhancement Recommendations Report & Presentation

This draft report, documents the efforts and findings of Phase I, Tasks One through Task Five.

### 3 BACKGROUND

Madison County is in central Virginia and is approximately 322 square miles. It has a population estimated in 2016 of 13,078<sup>1</sup>. According to the US Census data the population decline from 2010 was at 1.7%. The Town of Madison is the County Seat for Madison County. The counties that are adjacent to Madison County are Page (northwest), Rappahannock (north), Culpeper (east), Orange (southeast), and Greene (southwest).



The following contains the map of the County, its boundaries and other GIS data:

<https://www.webgis.net/va/madison/>

**The towns in the County include:**

Madison (County Seat)

**The census-designated places in the County include:**

Brightwood

**The unincorporated communities in the County include:**

Achsah	Elly	Locust dale	Rochelle	Wolftown
Aroda	Etlan	Madison Mills	Ruth	Zeos
Aylor	Five Forks	Nethers	Shelby	
Banco	Fletcher	Novum	Shifflet Corner	
Beaver Park	Fordsville	O'Neal	Syria	
Big Meadows	Graves Mill	Oakpark	Tanners	
Burnt Tree	Haywood	Oldrag	Tryme	
Criglersville	Hood	Pratts	Twyman's Mill	
Decapolis	Kinderhook	Radiant	Uno	
Duet	leon	Repton Mills	Waylandsborg	

<sup>1</sup> <https://www.census.gov/quickfacts/fact/table/madisoncountyvirginia/AGE275210>



## 4 MADISON COUNTY PUBLIC SAFETY SERVICES

### 4.1 LAW ENFORCEMENT

The Madison County Sheriff's Office is the primary law enforcement agency in the county.<sup>2</sup>

### 4.2 MADISON COUNTY VOLUNTEER FIRE DEPARTMENT

The County is served by all-volunteer fire department.

### 4.3 MADISON COUNTY RESCUE SQUAD

The Madison County Rescue Squad is a volunteer organization that provides Emergency Medical Services (EMS) to Madison County and mutual aid to surrounding communities (Greene, Culpeper, Rappahannock and Orange counties).<sup>3</sup>

The major area hospitals are UVA Culpeper Hospital (Culpeper, VA), Martha Jefferson Hospital (MJH) and University of Virginia (UVA). MJH and UVA are in Charlottesville.

### 4.4 MADISON COUNTY EMS

Madison County Emergency Medical Services (MEMS) is the career department providing emergency medical care to the citizens of Madison County, Virginia. MEMS is available seven days a week from 5:00 am to 6:00 pm by dialing 911. Every staff member holds an advanced life support certification as well as vehicle rescue certification. Additionally, most are trained in at least one technical rescue discipline<sup>4</sup>.

### 4.5 MADISON COUNTY E-911

The Madison County 911 Dispatch Center located at 115 Church Street, Madison, VA is the primary Public Safety Answering Point (PSAP) for all of Madison County.<sup>5</sup>

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<sup>2</sup> <http://www.madisonco.virginia.gov/sheriff.php>

<sup>3</sup> <https://sites.google.com/site/madisoncountyrescuesquadinc/>

<sup>4</sup> <http://www.madisonco.virginia.gov/ems.php>

<sup>5</sup> <http://www.madisonco.virginia.gov/e911.php>

## 5 DESCRIPTION OF EXISTING RADIO SYSTEM

Public safety agencies in Madison County operate a 5-channel (9 talkpaths) conventional VHF Motorola **MOTOTRBO™** digital radio system. The five channels are: Sheriff, Fire, Rescue, County and Public Works. Each channel provides two talkpaths. The systems are configured as follows:

1. The digital system is equipped with three independent sites at 911 Center, Blakey Ridge and Beautiful Run.
2. The users manually switch to the appropriate site when directed by the 911 Dispatch Center.
3. Blakey Ridge is the main or the default site being used for 80 – 85% of the transmissions.
4. There are also analog conventional stations at 911 Dispatch Center for backup.
5. All main sites operate on the same frequency pairs and are mirror of each other.
6. There is a separate Paging and Mutual Aid channel, 154.430 MHz, that is used for tone and voice paging of the volunteer fire department and EMS & Rescue. The paging system is not part of this upgrade and will continue to operate as is.
7. The digital channels are equipped with GPS location for both mobile and portable radios. The 911 Center makes use of StreeTrek<sup>6</sup> application software to display field radio's location.

The transmitter/receiver sites for the public safety channels are at the following locations:

Table 4: Primary Tower Site Locations

	911 CENTER	BLACKY RIDGE	BEAUTIFUL RUN
Latitude	38-22-38.5 N	38-25-39.5 N	38-18-43.0 N
Longitude	78-15-30.0 W	78-20-15.0 W	78-12-49.1 W
Tower Antenna Registration No. (ASR)	N/A	N/A	N/A
Ground Elevation (meters)	184	607.8	42.6
Address	107 Church Street, Madison, VA	Blacky Ridge, Aylor, VA 22727	Radiant, VA

<sup>6</sup> <http://www.streettrek.com/solutions/solutions-streettrek3-gps/>

The sites are shown in Figure 1 below.

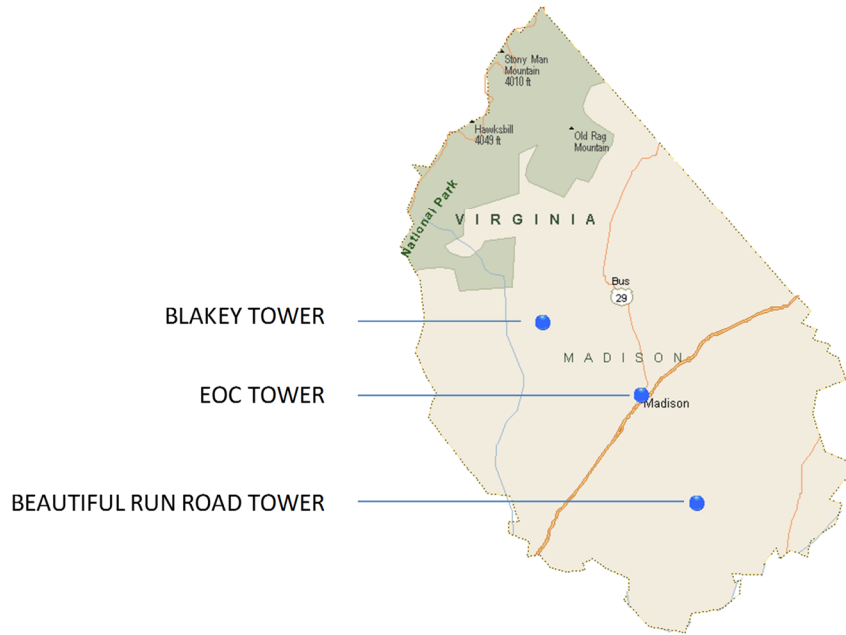


Figure 1: Primary Tower Site Locations Map

## 5.1 FREQUENCIES

Table 5 below provides a list of the VHF voice frequencies operated by Madison County.

Table 5: Madison County Primary Public Safety Frequencies

CHANNEL NAME	SHERIFF DISPATCH	FIRE DISPATCH	RESCUE DISPATCH	COUNTY	PUBLIC WORKS
Transmit Frequency (MHz)	154.800	154.355	155.385	151.325	151.1675
Receive Frequency (MHz)	155.730	159.045	154.070	156.210	158.7525
FCC Call Sign	WPJU625	WPJP622	KKL921	WQOG368	WQOG368

The system provides two talkpaths for each digital channel. Therefore, the above frequencies provide the following channels or talkpaths that can be used: Sheriff 1, Sheriff 2, Fire 1, Fire 2, Rescue 1, Rescue 2, County 1, County 2, and Public Works. There is also a 10th talkpath (or TDMA slot) that is used for GPS data.

There are additional frequencies used by Madison County shown in Table 6 below:

Table 6: Additional Frequencies Used by Madison County

CHANNEL NAME	TRANSMIT FREQUENCY (MHZ)	RECEIVE FREQUENCY (MHZ)	FCC CALL SIGN
SIRS	39.4200	39.5400	WPJU625
Paging/Mutual Aid	154.430	154.01	WPJP622
Rescue Simplex	155.235	155.235	KKL921

## 5.2 FCC LICENSE DATA

Research was conducted and the information below in Table 7 is included in the FCC database:

Table 7: Primary FCC Licenses for Madison County

CALLSIGN	STATUS	EXPIRATION	FRN	LICENSEE
WPJU625	Active	08/03/2025	2034098	Madison, County of
WPJP622	Active	02/06/2022	2066215	Madison County Volunteer Fire Company Inc.
KKL921	Active	02/22/2022	6366348	Madison County Rescue Squad Inc.

The County is also licensed for the following FCC call signs:

Table 8: Additional Madison County FCC Licenses

CALL SIGNS	STATUS	EXPIRATION	FRN	LICENSEE
WQOG368	Active	9/16/2021	2034098	Madison County

## 5.3 EQUIPMENT

The 911 Center Site at Madison, VA includes the following major equipment:

- Motorola MTR3000 TX/RX base stations in racks for the Sheriff, Fire, and Rescue channels (Qty 3)
- Motorola MTR000<sup>7</sup> TX/RX base stations in racks for Fire tone & voice paging (Qty 1)
- Motorola MTR3000 TX/RX base stations in racks for Sheriff analog (Qty 1)
- Motorola MTR3000 TX/RX base station in rack, as a spare unit (Qty 1)

<sup>7</sup> The MTR2000 base stations have been upgraded to same specs as MTR3000 with MTR2000 chassis.

- Transmit: VHF Antenna (PD200<sup>8</sup> 5.6 dBd Omni at 121' AGL) and 7/8" transmission line (Qty 1)
- Receive: VHF Antenna (PD200<sup>9</sup> 5.6 dBd Omni at 141' AGL) and 7/8" transmission line (Qty 1)
- Transmitter Combiner (Sinclair TJD-150-3)
- Receiver Multicoupler (DBMORX-08LC)
- Backup generator power available to this facility.
- The equipment is located inside the 911 equipment room.
- Motorola CENTRACOM Gold Elite electronics for the radio dispatch consoles
- XPR 4550 control station radios (Qty 6: SD1, FD1, RS1, GPS, County 1, Public Works)
- XPR 4550 control station radios (Qty 6: SD2 data, SD2 voice & data, FD2 voice & data, FD1, RS2, County 2)
- The tower is approximately 125-ft. small lattice tower (with guide wires for the upper sections of the tower) in the rear of the 911 building.

The Blakey Ridge (Aylor, VA) includes the following major equipment:

- Motorola MTR3000 TX/RX base stations in racks for the Sheriff, Fire, and Rescue channels (Qty 3)
- Motorola MTR3000 TX/RX base stations in racks for the Public Works and GPS channels (Qty 1)
- Motorola MTR000<sup>10</sup> TX/RX base stations in racks for Fire tone & voice paging (Qty 1)
- Transmit: VHF Antenna (ANT150D, Unity Gain Directional, at 60' AGL, with a 90-degree azimuth) and 7/8" transmission line (Qty 1)
- Receive: VHF Antenna (ANT150D, Unity Gain Directional, at 75' AGL, with a 90-degree azimuth) and 7/8" transmission line (Qty 1)
- Transmitter Combiner (Sinclair TJD-150-3)
- Receiver Multicoupler (DBMORX-08LC)
- Backup battery power
- Backup generator power
- The communications shelter (VFP, 12' x 10') is located next to the tower.
- The self-supporting tower within a fenced area. This site is owned by Madison County.

The Beautiful Run (radiant, VA) includes the following major equipment:

<sup>8</sup> or equivalent

<sup>9</sup> or equivalent

<sup>10</sup> The MTR2000 base stations have been upgraded to same specs as MTR3000 with MTR3000 chassis.

- Motorola MTR3000 TX/RX base stations in racks for the Sheriff (Sheriff 1 & Data), Rescue/Fire (Rescue 1 & Fire 1) and County (County 1 & County 2) channels (Qty 3)
- GE MASTR III TX/RX base station in racks for Fire tone & voice paging (Qty 2, Main & Backup)
- Transmit: VHF Antenna (ANT150F2, 2.5 dBd Gain Omni, at 140' AG) and 7/8" transmission line (Qty 1)
- Receive: VHF Antenna (ANT150F2, 2.5 dBd Gain Omni, at 190' AG) and 7/8" transmission line (Qty 1)
- Transmitter Combiner (Sinclair TJD-150-3)
- Receiver Multicoupler (DBMORX-08LC)
- Backup UPS and battery power
- Backup generator power
- The communications shelter (VFP Model 4056, with external dimensions: 126"x150"x126") is in proximity to the tower.
- The monopole tower (Rohn, 195' tapered steel pole) is within a fenced area. The tower is leased from Community Wireless Structures.

## 5.4 COMMUNICATIONS AREAS OF RESPONSIBILITY

### 5.4.1 PSAP and Dispatch Operations

The Madison County Public Safety Answering Point (PSAP) is located at 107 Church Street in Madison, VA and is managed by the Madison County E-911. The center has four multi-channel radio dispatch Motorola CENTRACOM Gold Elite consoles. The center dispatches fire, rescue, and police for the entire county.

### 5.4.2 Radio System Responsibility

The Madison County E-911 is responsible for the radio system, maintenance, and operation of the radio system and the PSAP. Maintenance is contracted to Clear Communications.

It is responsibility of each organization to take care of maintenance and operation of their own portable and mobile radios.

## 5.5 ASSESSMENT OF CURRENT SYSTEM EQUIPMENT

The following table indicates the status of the major equipment used for the Sheriff, Fire, and Rescue channel infrastructure.

Table 9: Sheriff, Fire and Rescue Channel Equipment

Site	Equipment	Comment, Useful Life
PSAP	Motorola Gold Elite Radio Consoles	Discontinued Cancel Date: 12/31/2011 End of Support Date: 12/31/2018

As shown in the above table, the radio consoles in use today are no longer current products and have been discontinued. The manufacturer's support typically ends 7 years after product is discontinued.

Because the County's console is aging and is approaching end-of-life or end of manufacturer's service support. The local contractor has indicated that they will continue maintain the system. However, Black & Veatch recommends that the County consider replacing its existing system once a direction has been determined for the radio system.

## 6 EXISTING SYSTEM ISSUES

### 6.1 SURVEY QUESTIONNAIRES AND USER INTERVIEWS CONDUCTED

Black & Veatch prepared and submitted two sets of survey questionnaires; a technical questionnaire for the Radio System Administer to collect the information pertinent to the current communications systems in use by the County, and a non-technical questionnaire to collect information from the radio users of the County's existing voice system.

Responses were received from the following agencies (The responses to the questionnaires are included in Appendix A).

### 6.2 RESPONSES TO QUESTIONNAIRE

Responses for the Survey Forms were received from the following agencies:

- Madison County E-911
- Madison County Sheriff's Office
- Madison County EMS
- Madison County Vol. Fire Co., Inc.
- Madison County Rescue Squad

Black & Veatch also interviewed the following agencies:

- Madison County E-911
- Madison County Sheriff's Office
- Madison County EMS
- Madison County Vol. Fire Co., Inc.

Table 10 below summarizes the information for the current public safety channels in Madison County and the issues and shortcomings being reported by the users.

Table 10: Subscriber Radios by Agency and Issues

Agency	# of Mobile Radios	# of Portable Radios	# of Pagers	Issues/Comments
Madison County E-911	20	40		<ul style="list-style-type: none"> <li>• Poor and unreliable radio coverage.</li> <li>• Channel Congestion when users trying to talk at the same time.</li> <li>• Occasional co-channel interference.</li> <li>• Frequent portable and mobile radio failures.</li> </ul>



Agency	# of Mobile Radios	# of Portable Radios	# of Pagers	Issues/Comments
Madison County Sheriff's Office	33 <sup>11</sup>	37 <sup>12</sup>		<ul style="list-style-type: none"> <li>• Poor and unreliable radio coverage</li> <li>• Interoperability with neighboring jurisdictions</li> <li>• Events with multi radios at one location causing the system to shut down.</li> <li>• Frequent channel congestion.</li> <li>• Co-channel interference</li> <li>• Frequent mobile and portable radio failures.</li> </ul>
Madison County EMS	5 <sup>13</sup>	13 <sup>14</sup>	12 <sup>15</sup>	<ul style="list-style-type: none"> <li>• Coverage issues: <ul style="list-style-type: none"> <li>○ Fair portable coverage; multiple locations that the users are not able to transmit clearly.</li> </ul> </li> <li>• Channel congestion during high call volume, MVC calls, and sever weather.</li> <li>• Interference (nuisance but not of destructive type) on voice pagers from Powhatan County.<sup>16</sup></li> </ul>
Madison County Vol. Fire Co., Inc.	9	40 <sup>17</sup>		<ul style="list-style-type: none"> <li>• Poor radio coverage <ul style="list-style-type: none"> <li>○ South Seminole Trail between South Main St. and the 1700 Block (transmit),</li> <li>○ Many areas with terrain issues</li> </ul> </li> </ul>

<sup>11</sup> Motorola XPR4550

<sup>12</sup> Motorola XPR6550

<sup>13</sup> Motorola XPR4550

<sup>14</sup> Motorola XPR6550 (Qty 11), HT1250 (Qty 2)

<sup>15</sup> Motorola Minitor V (qty 11), Minitor VI (Qty 1)

<sup>16</sup> The interference is of nuisance type and does not interfere with the paging operation. Pagers that continue to monitor the channel after completion of dispatch message may experience the presence of unwanted signal from Powhatan County. The user has the option of resetting the pager after receipt of the initial dispatch. In this scenario, the user will not hear the unwanted signal.

<sup>17</sup> Motorola XPR6550 (Qty 35), XPR7550e (Qty 5)

Agency	# of Mobile Radios	# of Portable Radios	# of Pagers	Issues/Comments
Madison County Rescue Squad	8 <sup>18</sup>	60 <sup>19</sup>	60 <sup>20</sup>	(both transmit and receive), <ul style="list-style-type: none"> <li>o Extreme south end of the county (transmit)</li> <li>o Extreme western side of the county (transmit and receive).</li> </ul>
				<ul style="list-style-type: none"> <li>o South Seminole Trail between South Main St. and the 1700 Block (transmit),</li> <li>o Many areas with terrain issues (both transmit and receive),</li> <li>o Extreme south end of the county (transmit)</li> <li>o Extreme western side of the county (transmit and receive).</li> <li>• Channel congestion during large scale incidents, and severe weather.</li> </ul>

<sup>18</sup> Motorola XPR4580 (qty 7 of the 8)

<sup>19</sup> Motorola XPR6550

<sup>20</sup> Motorola Minitor V

## 7 SUMMARY OF MAJOR CONCERNS AND CHALLENGES

In the course of reviewing the responses to the survey questionnaire and interviews, the following issues have been revealed:

1. Radio Coverage Issues:
2. Poor radio coverage is experienced by both Mobile and Portable radios.
3. Having to decide which site to use.
4. The reported areas of poor coverage are:
  - a. South Seminole Trail between South Main St. and the 1700 Block (transmit),
  - b. Many areas with terrain issues (both transmit and receive),
  - c. Extreme south end of the county (transmit)
  - d. Extreme western side of the county (transmit and receive).
5. Channel Congestion:
  - a. When users trying to talk at the same time.
  - b. During large scale incidents, and severe weather.
6. Interoperability:
  - a. Interoperability with neighboring jurisdictions.

## 8 INTEROPERABILITY

### 8.1 INTRODUCTION

“Interoperability is the ability of public safety personnel to communicate by radio with staff from other agencies on demand and in real time.”<sup>21</sup>

Madison County public safety agencies (Sheriff, Fire and Rescue) utilize the VHF conventional digital channels for their day-to-day communications. The radios however, are capable of switching to conventional non-digital VHF channels. All Madison County radios, both mobiles and portables are programmed with all of each organization’s channels so they can talk to each other except for Sheriff 2. Sheriff 2 can only be used and listened to by sheriff department personnel. Also, all radios have a zone programmed with all of the federal VHF mutual aid channels. There is also a zone programmed for Orange County (sheriff, fire & rescue) and a zone for Greene County (sheriff, fire & rescue). The County has interoperability with both Orange and Greene Counties. Culpeper & Rappahannock counties however, are on UHF and 800 MHz.

The County 911 Dispatch Center also has capability to communicate directly with County school buses<sup>22</sup>.

Due to the bandwidth limitations of most public safety radios, it is only possible to directly communicate with agencies operating within the same frequency band. Therefore, a public safety agency operating in the VHF band cannot communicate directly with agencies operating in the UHF or 800 MHz band. Consequently, interoperability between the public safety agencies within the county and neighboring counties is limited to those agencies operating within the same frequency band and radio system protocols, or to those operating within range of their own transmitter site(s) provided the systems are configured to provide network interoperability through some form of system interconnection. Alternatively, users may choose to carry multiple radios that operate on different frequency bands and protocols, or purchase relatively expensive multi-band and multi-protocol radios.

The following link, from Department of Homeland Security on interoperability continuum, provides tools in improving interoperability in emergency response communications:

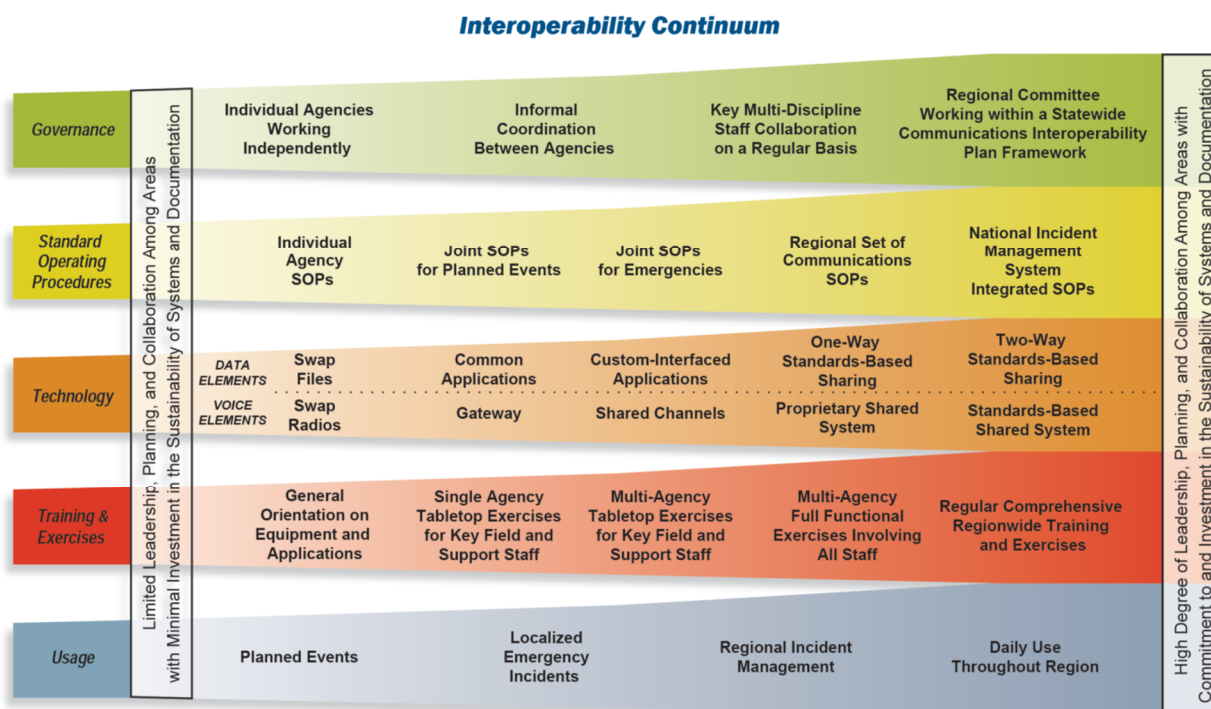
[https://www.dhs.gov/sites/default/files/publications/interoperability\\_continuum\\_brochure\\_2.pdf](https://www.dhs.gov/sites/default/files/publications/interoperability_continuum_brochure_2.pdf)

Following is an excerpt from “Interoperability Continuum Brochure” published by Homeland Security Safecom program:

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<sup>21</sup> <http://transition.fcc.gov/pshs/docs-basic/ntfi-interoperability0205.pdf>

<sup>22</sup> As part of Emergency and Disaster preparedness plan, the County makes use of the school buses for transportation in the event of emergency.



“To drive progress along the five elements of the Continuum and improve interoperability, emergency responders should observe the following principles:

- Gain leadership commitment from all disciplines (e.g., EMS, fire-rescue response, and Law Enforcement).
- Foster collaboration across disciplines through leadership support.
- Interface with policy makers to gain leadership commitment and resource support.
- Use interoperability solutions regularly.
- Plan and budget for ongoing updates to systems, procedures, and documentation.
- Ensure collaboration and coordination across all Interoperability Continuum elements.”

## 8.2 INTEROPERABILITY WITHIN THE COUNTY

Sheriff, Fire and Rescue operate in digital mode on conventional VHF channels. Interoperability between Fire, EMS and Sheriff occurs through a common channel. The patching of different channels can work as long as each user has adequate coverage under their respective system

## 8.3 INTEROPERABILITY OUTSIDE THE COUNTY

The County agencies are limited in capability when responding to neighboring agencies operating in different frequency band.

Interoperability with neighboring jurisdictions or State Agencies is acquired mainly by programming primary radio channels in each agency and jurisdiction’s radios. Jurisdictions providing mutual-aid assistance to Madison County do not have direct radio communications until

they arrive in the coverage area of the Madison County system. The same is true when Madison provides mutual-aid to other jurisdictions.

All Madison County radios already have all State and Federal interoperability channels programmed into them. These channels can be utilized when resources arrive on scene of an incident. In some cases, the agencies may provide a few radios programmed on their respective systems so that interoperable communications can occur among the agencies at the scene.

Table 11 below provides a listing of the neighboring counties and the frequency band they operate on.

Table 11: Systems in Counties Around Madison County

County	Radio System	Frequency Band
Page (northwest)	Conventional, Analog	UHF
Rappahannock (north)	Trunked (Motorola Type II SmartZone)	800 MHz
Culpeper (east)	Trunked (Motorola Type II SmartZone)	800 MHz
Orange (southeast)	Conventional, Analog, Sheriff's Office on Motorola Digital MOTOTRBO™	VHF
Greene (southwest)	Fire/EMS on Conventional, Analog, Sheriff's Office on Motorola Digital MOTOTRBO™	VHF

## 8.4 INTEROPERABILITY AVAILABLE VIA PSAP

The 911 Center when equipped with appropriate mutual aid channels. Upon a request by the field, the appropriate message can be relayed through the dispatcher or in some instances a temporary patch of the channels may be made for the duration of the call. The patch process however will tie up the channels on both systems for the duration of the call.

The PSAPs in the region can also be equipped with a common channel(s) for intercommunications among the PSAPs.

## 9 TECHNOLOGY DESCRIPTIONS AND ENHANCEMENTS

### 9.1 RADIO COVERAGE, DEFINITION AND OBJECTIVES

The generally accepted goal for a public safety communications system is to provide radio coverage at 95% reliability for a specified service area.

The Telecommunications Industry Association (TIA), in TIA/EIA Technical Service Bulletin TSB-88 defines the delivered audio quality, which is a numeric rating of speech intelligibility, as shown in Table 12 below:

Table 12: Delivered Audio Quality (DAQ) Levels

DELIVERED AUDIO QUALITY NUMERIC RATING	
DAQ 1.0	Unusable. Speech present but not understandable.
DAQ 2.0	Speech understandable with considerable effort. Requires frequent repetition due to noise/distortion.
DAQ 3.0	Speech understandable with slight effort. Requires occasional repetition due to noise/distortion.
DAQ 3.4	Speech understandable without repetition. Some noise/distortion present.
DAQ 4.0	Speech easily understood. Occasional noise/distortion present.

The recommended audio quality for Public Safety operation is DAQ 3.4. The minimum acceptable audio quality for analog systems is DAQ 3.0. The vendors providing analog systems typically guarantee coverage at DAQ 3.0. Vendors do guarantee coverage at DAQ 3.4 for digital systems.

Radio coverage reliability is based upon statistical modeling and provides information about how reliably a user in the field can be expected to communicate with his/her dispatcher or other field personnel. For example, a reliability factor of 95% indicates that the radio user should have a 95% probability of successful communications at various locations throughout a region.

A 95% radio coverage reliability requirement, which is generally the performance “benchmark” for public safety systems, is recommended for Madison County. This requirement may require a greater number of sites than a system designed for 90% reliability. On a per site basis, the radio coverage footprint associated with a site in a system designed for 90% reliability is larger than the coverage footprint for a system designed for a higher reliability. Therefore, in a system with 95% reliability the user is more likely to communicate from any given point when compared to a system designed for 90% or lower reliability. Communications on the periphery of the coverage footprint is also more problematic for a system designed for 90% reliability than a system with 95% reliability.

### 9.2 APCO PROJECT 25

Beginning in 1989, a standard for digital radio and trunking operation was initiated to address the problems of incompatibility of advanced radio systems. Project 25 (P25) is the interoperability standard for digital two-way wireless communications products and systems. The P25 standard was created by and for public safety and federal communications professionals to provide specifications for the design of communications systems so that all purchasers of P25 compatible

equipment operating in the same frequency band can communicate with each other. A P25 system can be used in conventional or trunked mode of operation. In a trunked mode of operation, the radio traffic is automatically assigned to an available repeater by the trunked system controller.

The original goals of the Project 25 standards (and their benefits) are to:

***Allow effective, efficient, and reliable intra-agency and inter-agency communications*** - so organizations can easily implement interoperable and seamless joint communication in both routine and emergency circumstances.

***Ensure competition in system life cycle procurements*** - so agencies can choose from multiple vendors and products, ultimately saving money and gaining the freedom to select from the widest range of equipment and features.

***Provide user-friendly equipment***- so users can take full advantage of their radios' lifesaving capabilities on the job – even under adverse conditions – with minimal training.

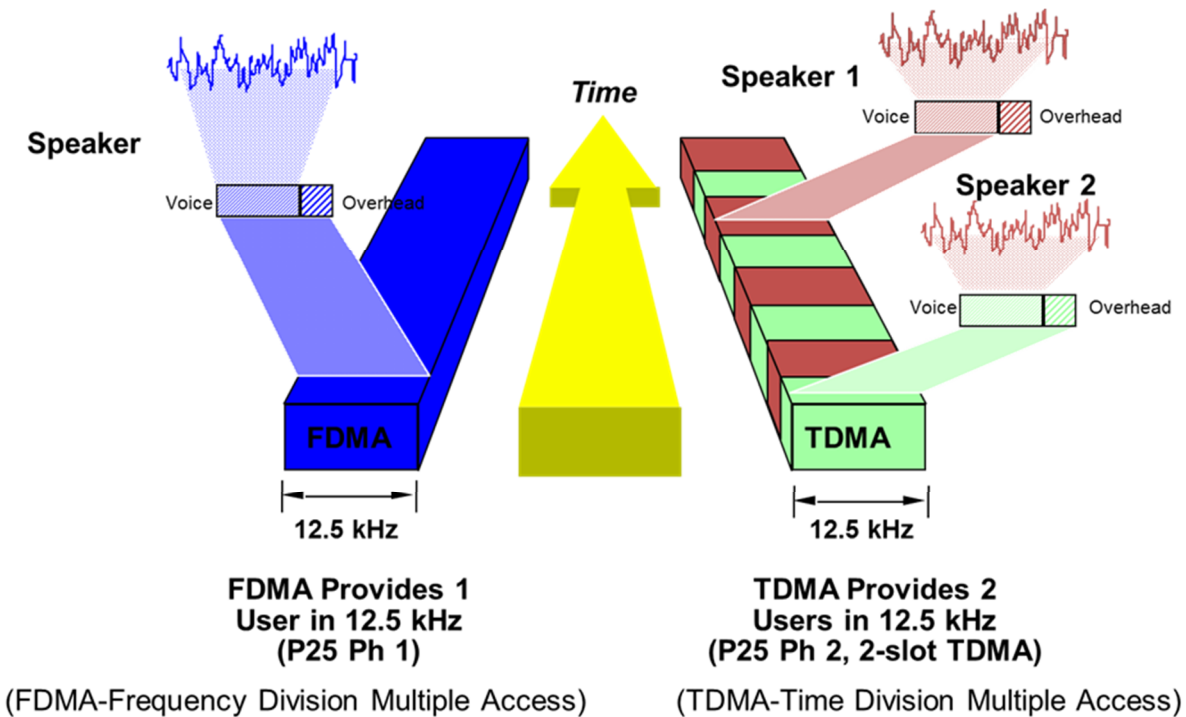
***Improve radio spectrum efficiency***- so systems will have enough capacity to handle calls and allow room for growth, even in areas where the spectrum is crowded and it is difficult for agencies to obtain licenses for additional radio frequencies.

It is important to note that there is frequently confusion among radio system users about the adoption and use of "Project 25". While P25 does establish a common air interface between radio equipment from different manufacturers, it does not specify a particular frequency band for operation. This means that if an agency operates VHF P25 radio equipment and a neighboring agency operates UHF or 800 MHz P25 radio equipment, they still will not be able to communicate with one another directly over the air due to the different frequency bands. Some form of multi-band radio or cross-band patching or linking of the radio systems will still be required to allow the two agencies to communicate with one another by radio.

### 9.2.1 P25 Phase 1 and 2

- Phase 1 of the P25 standard calls for radio channels to be spaced at 12.5 kHz and occupying a bandwidth of 11.25 kHz.
- P25 Phase 1 provides a data rate of 9600 BPS at 12.5 kHz channel spacing and supports one voice channel.
- P25 Phase 2 is now available by a number of vendors. It is backward compatible with Phase 1, uses the same control channel protocol but splits the working channels into two (2) TDMA slots, thus effectively doubling the number of working channels available in a given system without the need to acquire new frequencies. The air link rate increases from Phase 1's 9.6 kb/s to 12 kb/s. The modulations changes from 4-level Frequency Shift Keying (C4FM) on both uplink and downlink to H-DQPSK for downlink and H-CPM for uplink.





**Figure 9.2.1-1 P25 Multiple Access Protocols**

P25 distinguishes between mandatory and optional features. All radios and systems claiming P25 compliance must meet the mandatory requirements and provide at least basic level of compatibility. Some functions are still implemented using proprietary technologies. For example, Over-The-Air-Rekeying (OTAR), the ability to change encryption key remotely, is standardized and a system from one vendor can deliver that feature to subscriber units from different vendors, while Over-The-Air-Programming (OTAP) is a proprietary feature, which means that the equipment from different users is not compatible.

Although each of the vendors supplies radio systems that provide trunking features, there are some differences between each vendor's approaches. Significant progress has been made recently in ensuring compatibility for equipment from different vendors. Specifically, Department of Homeland Security (DHS) instituted a compatibility testing program and most of the vendors make big effort to achieve the certification of compliance. The adoption of a common standard allows radios from one vendor to work on another vendor's system, allowing more freedom in equipment procurement, and greater interoperability between neighboring trunked systems.

### 9.2.2 Inter RF Subsystem Interface (ISSI)

The use of Inter-RF Subsystem Interface ("ISSI") technology is made to interconnect disparate P25 systems. The technology allows, through the use of a common communications (wireless) layer, software can configure subscriber radios to seamlessly roam between the infrastructures of multiple states, counties, cities or other units of government.

While the ISSI allows in physically connecting systems to provide wide area communications platforms, multi-system planning (i.e., Albemarle County) may be required to gain the full benefit of

the technology. As part of the planning, each system will need to be assigned a block of unique identification numbers to be used when configuring radios.

### 9.2.3 Console Subsystem Interface (CSSI)

The Console Subsystem Interface (CSSI) is included as part of the ISSI interface. The standards are being developed and different console manufacturers are developing their own method of integrating their system into the ISSI interface. The key items that will need to be exchanged between the P25 radio infrastructure and radio console are the vocoder and algorithms used for encoding and decoding voice and the encryption key used. Continued testing of new versions of manufacturer's software upgrades will need to be performed to assure continued interoperability.

## 9.3 ANALOG VOICE VS. DIGITAL VOICE SYSTEMS

The digital audio clarity can be better and more consistent throughout the entire coverage area when compared to analog audio. In an analog system, experienced users can determine in advance when they are nearing the limits of radio coverage as the amount of receiver noise present increases proportionately as the signal levels decrease.

In a digital system, the audio quality remains clear as the receiver moves away from the transmitter and the signal levels decrease in strength. Only when the radio signal strength decreases to the point where the digital bit error rate becomes excessive, does the audio quality begin to deteriorate. When the radio user is at this point, the drop out of radio communications is quite abrupt when compared to the gradual degradation of an analog system.

## 9.4 CONVENTIONAL VS. TRUNKING

### 9.4.1 Conventional Systems

Conventional communication systems have been serving public safety agencies for many years and have proven to be very effective in meeting the basic communications needs of an agency. The VHF voice communications systems maintained by the County Fire and Rescue is an example of a conventional system where there is a "one-to-one" relationship between each radio channel, frequency, and base station, and the group of users assigned to the channel. Each group always uses the same radio channel for their communications. A failure of a base station on a particular channel will result in a total loss of communications for the agency on that channel<sup>23</sup>.

### 9.4.2 Trunked Systems

Much like a trunked telephone system where the needs of a group of users can be provided most efficiently by the sharing a number of common telephone trunk lines, trunked radio systems share the radio channels in the same way. The essence of trunking is the automatic sharing of a group of common communication radio channels or "talk paths" among a number of users.

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<sup>23</sup> For Madison County, the agency is directed to use another channel.

When user on the radio system initiates a call, he or she is automatically assigned a radio channel for the duration of that call. Once the conversation is completed, that same radio channel becomes available to other users. The sharing of radio channel resources is managed efficiently and automatically by the controller switching equipment.

A trunked wireless voice radio system can accommodate many groups of users per frequency by creating "virtual radio channels" known as trunked "talkgroups". Each user group is assigned one or more talkgroups for their use. Even though they are sharing a common pool of radio channels with the other user groups, each talkgroup behaves as if it were an exclusive radio channel. Only traffic belonging to that talkgroup is heard by the members of that talkgroup. Trunked radio systems allow many users and user groups to comfortably share a radio system especially where the number of talkgroups required is greater than the number of radio channels available.

Trunked radio is inherently redundant, which increases system reliability. If a failure of a radio channel should occur, the system controller detects the failure and does not assign the failed channel for service. The remaining channels are assigned normally, and the users usually do not notice a difference in their operation. One channel of the trunked system is designated as the "control channel" upon which the system controller communicates with the user equipment providing status updates and channel assignments. Trunked radio systems offer features that are unavailable on conventional systems such as the ability to provide multiple talkgroups, which enables agencies to communicate most efficiently and better segregate communications groups within and among agencies.

## 9.5 VOTED RECEIVE ONLY TECHNOLOGY

This section describes a voted receive only technology that may be utilized in LMR systems. The current County system sites operate independently and do not make use of satellite receivers. When a radio user transmits on a mobile or portable radio, the system determines which site is receiving the strongest signal level and transmits that radio traffic into the repeater system and it is then retransmitted from the main transmitter site.

## 9.6 SIMULCAST SYSTEMS

Simulcast systems utilizes multiple transmitters at different locations, simultaneously transmitting identical information on the same frequency. The transmitters are located so that their coverage areas overlap and their combined coverage provides a strong signal at all points within the desired coverage area.

The transmitters' frequency and modulation characteristics are held to extremely close tolerances, because even small differences between transmitters will result in a large amount of distortion, interference, and possibly a total loss of reception in the overlap zones. Modern simulcast systems make use of GPS receivers and very stable reference clocks to achieve the desired results. Mobile units do not change frequency as they travel between the coverage areas of the individual transmitters.

### Advantages

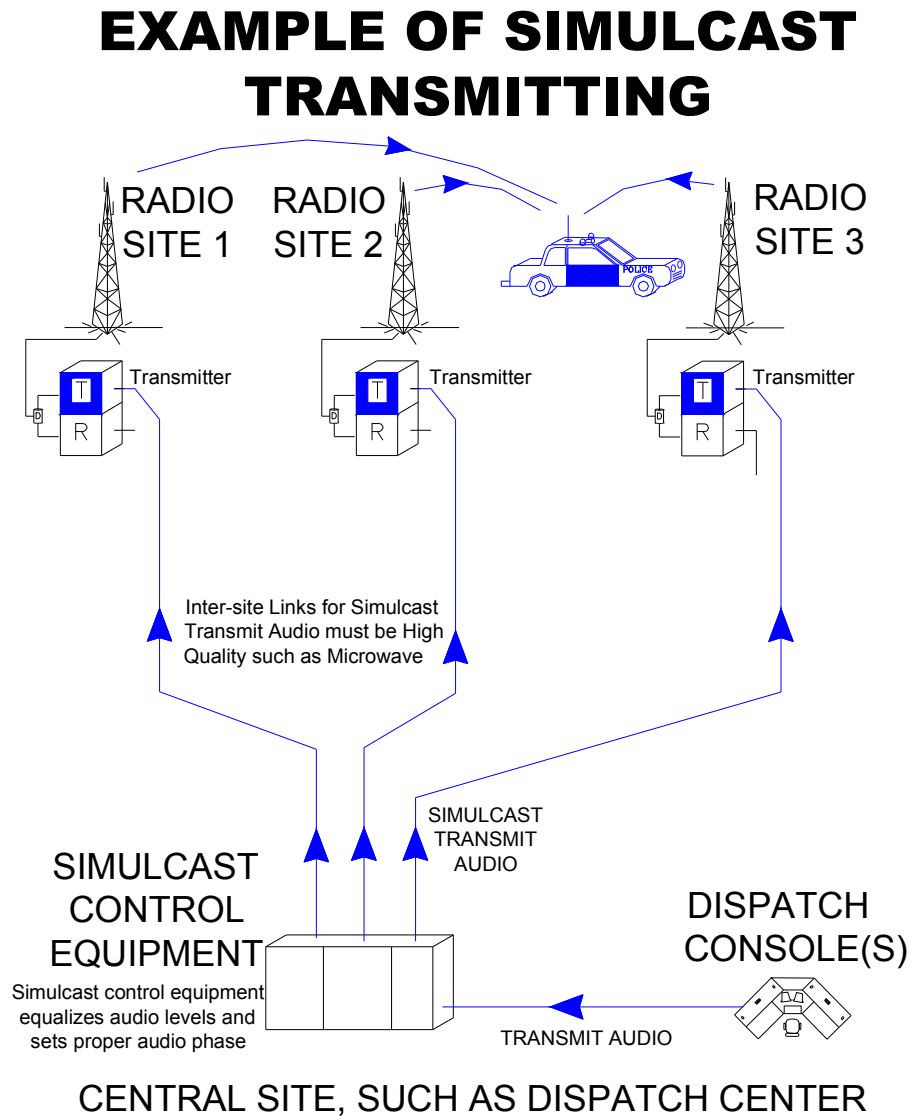
- Coverage is greatly improved because signals emanate from more than one direction.

- Subscriber unit operation is simple, without the need for switching channels or “roaming” as units move to other transmitter sites in other regions of the coverage area.
- A single frequency can be used throughout a large area.

Disadvantages

- Precision base station equipment resulting in higher costs is required to lock all transmitters on the same frequency and to ensure signal levels and phase do not change.
- High quality links such as digital microwave, fiber or T1s are needed to carry signals to the base transmitter.
- Higher implementation costs due to system complexity.
- Higher recurring maintenance costs due to system complexity.

Figure 2: Example of a Simulcast System



## 9.7 DMR BASED TECHNOLOGY

Digital Mobile Radio (DMR<sup>24</sup>) is a European<sup>25</sup> umbrella standard developed for non-Public Safety users. It is a robust and spectrum efficient technology with growing number of suppliers marketing their products in the United States. The most notable and common are Motorola's **MOTOTRBO™** and Tait.

The commercial offering of the DMR products include the following two tiers:

- DMR Tier II (Conventional) –Digital system providing two-slot TDMA in a 12.5 KHz channel.
- DMR Tier III (Trunked) –Digital trunked system also providing two-slot TDMA in 12.5 KHz channels.

Despite the fact that they are all based on the same umbrella standard, these technologies are not compatible.

Madison County main radio system is Motorola **MOTOTRBO™** conventional digital system.

## 9.8 BROADBAND

### 9.8.1 First Responder Network Authority (FirstNet)

First Responder Network Authority (FirstNet) (<http://www.firstnet.gov/>) was created as a result of the Middle-Class Tax Relief and Job Creation Act that was signed into law on February 22, 2012. The FirstNet mission is to build, operate and maintain a nationwide high-speed wireless broadband network dedicated to public safety. Toward this effort, Congress has allocated spectrum and up to \$7 billion in funding for the construction of the network.

All 56 U.S. States and territories will be required to have a radio access network (RAN) that will be connected to FirstNet Core network. FirstNet will be exploring public/private partnerships to leverage existing telecommunications infrastructure and assets to contain costs and accelerate the build out of the network.

FirstNet is an independent authority within the U.S. Department of Commerce's National Telecommunications and Information Administration. FirstNet is governed by a 15-member Board consisting of the Attorney General of the United States, the Secretary of Homeland Security, the Director of the Office of Management and Budget, and 12 members appointed by the Secretary of Commerce. The FirstNet Board is composed of representatives from public safety; local, state and federal government; and the wireless industry.

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<sup>24</sup> [www.dmrassociation.org](http://www.dmrassociation.org)

<sup>25</sup> European Telecommunications Standards Institute (ETSI)

The network will be based on Long Term Evolution (LTE) service and use of 700 MHz frequency band (D-Block: 758-763 MHz / 788-793 MHz). LTE or also referred to as 4G LTE is a commercial standard currently being deployed on cellular services.

The network is expected to initially transmit high-speed data, video and other features such as location information and streaming data. The network is not expected to replace the current land mobile radio (LMR) for mission-critical-voice.

FirstNet is working closely with public safety organizations to support development of standards and functionality suitable for mission-critical-voice (MCV) to be deployed on the network. The MCV application over LTE discussions include push-to-talk and direct unit-to-unit voice calls bypassing the system. This is a future application and probably several years away, perhaps 8 to 15 years in the future till the users are comfortable using the feature and is field proven.

## 9.9 FCC CURRENT AND FUTURE MANDATES

### 9.9.1 Radio Spectrum Used by First Responders

From an operational standpoint, most first responder agencies generally make use of six radio bands for their two-way radio systems. These include:

- Low Band (30-50 MHz)
- VHF (150-174 MHz)
- UHF Band (450-470 MHz)
- UHF "T" Band (470-512 MHz limited to certain major metropolitan areas)
- 700 MHz (769-775 MHz and 799-805 MHz)
- 800 MHz (Conventional and Trunked)

The County's current system makes use of the VHF frequency bands.

## 9.10 BACKHAUL NETWORK FOR PUBLIC SAFETY SYSTEMS

The new P25 public safety networks are IP based systems. They make use of exclusively or a combination of reliable digital microwave, fiber, and leased lines to interconnect the network including the radio sites, and the PSAPs. The new systems require the radio network to be independent and isolated from the other County's private IT networks.

### 9.10.1 Fiber-optic

Fiber-optic cable is used to transmit high bandwidth data over short or long distances. It has many advantages over other options such as copper cable including being insusceptible to electrical interference, avoids cross-talk between transmissions in adjacent or nearby cables, and is immune to environmental noise. The construction cost is high when compared to microwave and it requires right-of-way. It can be installed underground or overhead depending on the environment. The data compiled by the U.S. Department of Transportation, indicates the per mile costs of \$6,800 to \$79,000 for projects in the United States from 2001 to 2013

(<http://www.itscosts.its.dot.gov/its/benecost.nsf/DisplayRUCByUnitCostElementUnadjusted?Read>)

[Form&UnitCostElement=Fiber+Optic+Cable+Installation+&Subsystem=Roadside+Telecommunications+\)](#)

There are also capital costs for electronics connecting to the provided “dark’ fiber, which then is referred to as “lit” once operational.

### 9.10.2 Point-to-Point Microwave Radio Systems

Microwave radio provides a cost-effective, high-quality transmission medium for ever-demanding telecommunication services. Historically, microwave radio was used for high-capacity trunk routes for telephone companies. However, public safety agencies in the United States have used microwave almost from its inception, due its high reliability as well as safety and security concerns. Commercial operators, who also used microwave since their inception, gradually migrated their high capacity microwave networks to even higher capacity fiber-optic networks. During this transition, public safety’s use of microwave radio continued to grow. Other wireless operators, such as cellular and PCS, have also been using this technology for interconnecting short haul links as well as large backbone structure (e.g. Verizon operates a microwave backbone from New York down the East Coast into Texas).

Microwave radio networks have advantages over wired systems, because there is no physical medium connecting end locations. This is done using radio waves. These networks can be easily deployed because no cable must be installed between end points, thus making the initial investment cost low.

Microwave radio uses spectrum in the 6 GHz to 40 GHz range. These frequencies are transmitted using parabolic dish antennas located on towers between two fixed locations that have line-of-sight. Distances between end points can be up to 30 miles, depending on what frequency band is used and what path reliability is required. In respect to path reliability, the higher the frequency, the less distances identical data rates can be transmitted without upgrading antennas or radio equipment. On some frequencies, weather – such as rain, snow, or moisture – can attenuate signals. Microwave engineers must consider these conditions when designing a microwave path.

Point-to-point microwave radio systems can be implemented in a ring, linear string or star configuration or a combination of each for backbone networks and can accommodate data rates up to 155 Mbps. Microwave engineers must factor all applicable configurations to determine overall network reliability.

For public safety microwave radio networks, available frequencies are found in below.

Table 13: Microwave Frequency Bands

FREQUENCY BAND	FREQUENCY BAND [GHZ]	COMMENTS
6 GHz	5.9 to 7.1	Current Primary High Capacity Microwave Band
11 GHz	10.7 to 11.7	High Capacity Microwave Band
18 GHz	17.7 to 19.7	Low to Medium Capacity Microwave Band



FREQUENCY BAND	FREQUENCY BAND [GHZ]	COMMENTS
23 GHz	21.2 to 23.6	Low to Medium Capacity Microwave Band

### Summarizing Microwave:

- Has been the workhorse of public safety wireless transport systems nationwide.
- Line-of-sight high capacity radio system (point to point).
- Can support aggregate line rates of up to 155 Mbps per radio channel between locations.
- Multiple radio channels between locations possible.
- Highly reliable [99.9999% or greater], and typically used to support public safety applications.
- Requires FCC licensing for operation.
- Licensee's frequency is protected; thus, user has the ability to easily identify interfering signals and has recourse to mitigate.

## 9.11 KEY DATA NETWORK CONCEPTS - DATA PROTOCOLS AND SWITCHING

The delivery of data from one point to another utilizes one of two basic connection schemes: circuit switching or packet switching.

### 9.11.1 Circuit Switching

Circuit switching uses a dedicated channel, or circuit, that establishes a communications channel for the duration of the data transmission. An example of a circuit-switched network is a dedicated leased line between two or more locations. Another is the telephone company's dial-up network, where various copper wire segments are linked, creating a dedicated single line between two locations. The modern voice communications network is moving away from dedicated site backhaul or circuit-switched networks to a shared network by use of Ethernet technology,

### 9.11.2 Packet Switching

Packet switching is an advanced technique that divides the data messages into packets, which are then sent individually. These packets are routed, potentially taking several different routes to their final destination, where the packets are re-assembled. There is no need for dedicated leased lines. The Internet is an example of a packet switch network.

Packet switching networks are also referred to connectionless networks. However, a network can be configured as a connection-oriented network by using a higher-level protocol, such as X.25, Frame-Relay and IP. ATM networks attempts to combine the best of all worlds; that is, it guarantees the delivery of data just as circuit-switched networks can but with efficiencies of packet-switching networks. Current packet-switched technology now provides far more sophistication, allowing greater efficiencies, less transmission delays, and bandwidth management, all of which form the notion of Quality of Service (QoS).

### 9.11.3 Quality of Service (QoS)

QoS is a networking term that specifies a guaranteed traffic throughput level. Voice and video transmissions cannot be interrupted and cannot tolerate delays; therefore, data networks need to provide QoS control. QoS is also referred to as IEEE 802.1p which specifies the priority levels for delivering the traffic through the network. The recommended level for mission critical voice applications is Priority 4.

### 9.11.4 Internet Protocol

In a very short time period, the Internet and the Internet Protocol (IP) have revolutionized data networks. Its predominant force has changed the way we do business. The Internet's beginnings go back to the 1960's, but it did not achieve wide spread usage until the development of a Graphical User Interface (GUI) that became available in the middle 1990s. The World Wide Web (WWW) GUI, and the emergence of Internet service providers (ISP), have evolved the Internet into a large worldwide packet-switch data network.

The IP's main task is addressing, which allows the routing of IP packets between computers, with each packet having the IP routing address. The IP network is composed of several elements, mainly routers and permanently connected hierarchical computers, each having an IP address. Routers may have multiple IP addresses. Another protocol, known as Transmission Control Protocol (TCP), ensures that the IP packets arrive in order and without errors. TCP does this by making a logical connection between the source and destination computers, checks out errors and retransmit frames if errors found, and rearrange packets if they arrive out of order.

The current required version of IP for the mission critical networks is IPv4.

### 9.11.5 Emergency Services IP Network (ESInet)

PSAPs in various parts of the country are migrating toward deployment of ESInets for their next generation 911 PSAP connections. ESInet are broadband and IP based lines that make use of packet switched technology. The lines are standard based and can carry voice and other data such as video. They are engineered lines for redundancy, resiliency, and timing of data and can be configured as "network of networks" as in local, regional, state and national.

### 9.11.6 Multiprotocol Label Switching (MPLS)

Multiprotocol Label Switching (MPLS) is a networking protocol sometimes referred to as layer 2.5<sup>26</sup>. It is used in multi-service networks. The protocol allows managing network capacity, prioritizing disparate types of services to avoid network congestions. MPLS works by tagging the

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<sup>26</sup> Open Systems Interconnection (OSI) is a reference model for applications communicating over a network. It is divided into 7 layers (<https://support.microsoft.com/en-us/kb/103884>). Layer 2 is the Data Link Layer such as Ethernet. Layer 3 is the Network Layer which handles the addressing of the packet, the IP address. The MPLS is referred to as Layer 2.5 which is in between the two OSI layers by routing the packets by their labels instead of IP addresses.

traffic (i.e., packets) with an identifier or label and routes to the intended node(s). So, the traffic is routed faster based on short path labels instead of longer network addresses. The routing mechanism also avoids the complex lookups in the routing table.

## 9.12 FIRE PAGING ON P25 PUBLIC SAFETY RADIO SYSTEMS

Unication USA, Inc. of Arlington, Texas<sup>27</sup> has developed a P25 trunking pager that is capable of providing a user with the ability to receive individual department alerts and voice traffic from a P25 trunked radio system. The pager uses technology similar to a portable scanner and has a “talkgroup based alert” over the state system. However, the ability to page using QCII has been developed.

The technology to provide a fire paging system on a P25 Phase 2 trunked simulcast systems is still being developed by Unication and they have been conducting Beta tests. They plan to introduce their product after testing is completed in the first quarter of 2018.

There are several states have chosen to implement the Unication Pager as a solution to fire paging. Among those states are: Michigan, Ohio, Wisconsin, and Minnesota.

The pagers can be purchased as single or dual band pagers and are available in VHF, UHF and 700/800 MHz.

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<sup>27</sup> <http://www.unicationusa.com/>

## 10 EVALUATION AND RECOMMENDATIONS FOR A LMR SYSTEM MIGRATION PLAN

### 10.1 EXISTING SYSTEM COVERAGE PREDICTION

Coverage predictions for the current Sheriff, Fire and Rescue channels when all elements of the system including antenna and subscriber radios including their accessories are operating correctly, are shown in Appendix B. The analysis was performed for portable on-street, and inside building penetration losses of 6 dB, 12 dB and 20 dB. The portable configuration is assumed to be on hip with a remote speaker-mic attachment for outbound (i.e., dispatch to portable radios in the field) and inbound scenarios.

Table 14 below provides the mean building penetration losses used for predicting the in-building coverage:

Table 14: VHF Building Penetration Losses (in dB)

Building/Structure Type	VHF
Wood Frame	6
Medium size building of stucco and wood material	12
Large structure such as shopping centers	20

The coverage shown represents 95% area reliability with a voice quality of DAQ 3.4 or better for outdoor and 95% for indoor. The following tables show a summary of the Mobile and Portable coverage in relation to the County as the target service area.

Table 15: Radio Coverage - VHF Sheriff/Fire/Rescue Digital

#### Portable On-Hip with Remote Speaker Mic, Antenna on Portable Coverage Area (% of Madison County Area)

Existing Configuration Radio Coverage Scenarios	Site	Outdoor (On-street)	Portable Indoor (6 dB)	Portable Indoor (12 dB)	Portable Indoor (20 dB)
Mobile Coverage – Outbound/Inbound	911 Center	92.2%/94.2%	---	---	---
Portable on-hip Coverage – Outbound/Inbound		64.6%/41.6%	44.9%/26.7%	29.2%/15.4%	14.2%/5.8%
Mobile Coverage – Outbound/Inbound		83.7%/94.1%	---	---	---

**Portable On-Hip with Remote Speaker Mic, Antenna on Portable  
Coverage Area (% of Madison County Area)**

Existing Configuration Radio Coverage Scenarios	Site	Outdoor (On-street)	Portable Indoor (6 dB)	Portable Indoor (12 dB)	Portable Indoor (20 dB)
Portable on-hip Coverage – Outbound/Inbound	Blakey Ridge	<b>62.1%</b> /64%	<b>49.6%</b> /51.7%	<b>28.0%</b> /31.4%	<b>2.2%</b> /3.0%
Mobile Coverage – Outbound/Inbound	Beautiful Run	<b>76.4%</b> /82.5%	---	---	---
Portable on-hip Coverage – Outbound/Inbound		40.2%/23.9%	23.3%/13.9%	13.5%/6.8%	4.7%/1.3%

Radio signal strength coverage is a major concern expressed by current users of the radio systems both analog and digital. As illustrated, the indoor coverage degrades for larger buildings located farther away from the radio sites.

## 10.2 SUMMARY OF ALTERNATIVE CONSIDERED

Black & Veatch has constructed the following options and alternatives, all P25 trunked and in VHF frequency band. These alternatives and options are evaluated; each alternative is presented along with a discussion of its advantages and disadvantages. The analysis then concludes a long-term path for the County.

The following potential enhancement options for the voice communications systems are considered:

1. Madison County to procure and implement a stand-alone system –
  - a. In this option, Madison county implements its own stand-alone system, a 3-site, 4-channel simulcast system with a P25 core switch owned by Madison County.
2. Madison and Greene Counties to implement a shared system.
  - a. In this option, Madison and Greene counties implement a shared system. The shared options are as follows:
    - i. Madison County and Green County implement their own RF simulcast sites, each a 3-site, 4-channel, system, and share a common core switch.
    - ii. Madison County and Green implement a common 6-site, 7-channel RF simulcast system, with 3 sites, in each county, and share a common core switch.

3. Madison and/or Greene Counties to implement a shared, regional system with Fluvanna and Louisa Counties.
  - a. In this option, Madison and Greene counties implement their own RF simulcast sites, each a 3-site system, and share the existing core switch utilized by Fluvanna and Louisa Counties. The coverage and system capacity is the same as alternative 2a.
  - b. Or Madison County and Green implement a common 6-site RF simulcast system, with 3-sites in each county, and share the existing core switch utilized by Fluvanna and Louisa Counties. The coverage and system capacity is the same as alternative 2b.

The solutions offered here are general in nature. Note however, that the technology and coverage are only part of the overall process. Without cooperation, management, and the development of policies and procedures, no technical solution can be completely successful.

### 10.3 ALTERNATIVE 1 – MADISON COUNTY TO IMPLEMENT A STAND-ALONE SYSTEM

This option provides for the implementation of a four-channel stand-alone VHF P25 Phase 2 Simulcast trunked System that would provide six talkpaths. The preliminary system design follows the existing three sites but interconnected as a 3-site simulcast system.

The characteristic of this option are as follows:

1. This option assumes that the existing towers at 911 center, Blakey Ridge and Beautiful Run can be reused and that space is available for the County's new equipment at all three sites.
2. A new tower will likely be needed at 911 Center.
3. The new system will utilize linear simulcast technology improving the outbound coverage.
4. The new system will utilize receiver voting system improving the inbound coverage.
5. The new system is based on trunked mode of operation. Licensing VHF frequencies for trunked mode of operation requires concurrence from co-channel (within 7.5 KHz of 12.5 KHz operation) users within 113 km (70 miles).
6. A licensed 6 GHz microwave network interconnects the three sites.
7. The new system meets P25 standards; both Phase 1 and Phase 2.
8. The system makes use of enhanced dynamic dual mode trunking where Phase I subscriber units can operate on a P25 Phase 2 system.
9. This option requires new subscriber radios.
10. PSAP radio Consoles are replaced with new consoles.
11. The new PSAP radio consoles access the new system via new microwave links or leased ethernet lines to the new system.
12. The radio consoles are also equipped with backup RF control station radios in the event there is a failure in the backhaul network to the P25 core switch.
13. The current Fire paging channel will need to continue to operate as analog system to support the tone & voice paging operation.

### 10.3.1 Coverage Prediction – Alternative 1: Stand-Alone System

The coverage analysis of the proposed system using Black & Veatch model is contained in Appendix C. A summary of the results are as follows:

Table 16: Radio Coverage – County-wide VHF P25 Phase 2

Portable On-Hip with Remote Speaker Mic - Antenna on Portable  
Coverage Area (% of Madison County Area)

Radio Coverage Scenarios	Outdoor (On-street)	Portable Indoor (6 dB)	Portable Indoor (12 dB)	Portable Indoor (20 dB)
Mobile Coverage – Outbound/Inbound 3 sites: 911 Center, Blakey Ridge, Beautiful Run	96.7%/99.1%	---	---	---
Portable on-hip Coverage – Outbound/Inbound 3 sites: 911 Center, Blakey Ridge, Beautiful Run	82.9%/82.7%	71.7%/72.4%	56.2%/60.4%	29.1%/33.6%

### 10.3.2 Budgetary Cost Estimates – Alternative 1: A Stand-Alone System

The estimated costs<sup>28</sup> for Madison County to upgrade the current radio system to a standalone P25 Digital Radio System are shown in Table 17 below:

Table 17: Budgetary Cost Estimate – Stand-Alone P25 Digital Radio System

DESCRIPTION	COST
System Infrastructure	\$2,779,000
Master Site System Core	\$650,000
Three Site Fire Paging System	\$95,000
Systems Integration, Engineering, and Construction Services	\$1,319,000
IV&D GPS Unit Mapping Option	\$183,000
Subscriber Radios	\$862,000

<sup>28</sup> Rough order of magnitude

Total	\$5,888,000
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### 10.3.3 Advantage/Disadvantage of Alternative 1

The advantages and disadvantages of Alternative 1 – Standalone P25 Digital Radio System are shown in Table 18 below:

Table 18: Advantages and Disadvantages of Alternative 1

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can be monitored and recorded by Dispatch</li> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the system.</li> <li>• Extended battery operation when compared to analog radios</li> <li>• Alarm and control systems will be in place, which will alert the County when system failures occur. This will facilitate a timely response by the County's maintenance service provider.</li> <li>• Availability of P25 Phase 1 pager– P25 Phase 2 is being developed.</li> </ul>	<ul style="list-style-type: none"> <li>• FCC licensing – requires concurrence from co-channel users</li> <li>• The digital system is susceptible to co-channel interference</li> <li>• County is responsible for capital and recurring cost of the system.</li> <li>• Requires new subscriber radios</li> <li>• Higher cost subscriber radios</li> <li>• Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> </ul>

## 10.4 ALTERNATIVE 2 – MADISON AND GREENE COUNTIES TO IMPLEMENT A SHARED SYSTEM

In this option, Madison and Greene counties implement their own RF simulcast sites, each a three-site simulcast system and share a core switch. The coverage and system capacity is the same as alternative 1.

A variation of this option is to combine the two separate simulcast systems into one and connected to the core switch. A common simulcast system will save a control channel resulting in a 7-channel (12 talkpaths) simulcast system.



### 10.4.1 Coverage Predictions

Table 19 below provides a summary of results when a common simulcast system is utilized. The summary shows the following scenario:

- a 6-site simulcast system, three (3) sites in each county,

The coverage analysis of the proposed system using Black & Veatch model is contained in Appendix D.

Table 19: Radio Coverage - County-wide VHF P25 Phase 2

Portable On-Hip with Remote Speaker Mic - Antenna on Portable  
Coverage Area (% of Madison County Area)

Radio Coverage Scenarios	Outdoor (On-street)	Portable Indoor (6 dB)	Portable Indoor (12 dB)	Portable Indoor (20 dB)
Mobile Coverage – Outbound/Inbound (6 sites) Green County Sites: 3 sites: Ruckersville, Flat Top, Sheriff PSAP  Madison County Sites: 3 sites: 911 Center, Blakey Ridge, Beautiful Run	97.8%/99.4%	---	---	---
Portable on-hip Coverage – Outbound (6-Sites)  Green County Sites: 3 sites: Ruckersville, Flat Top, Sheriff PSAP  Madison County Sites: 3 sites: 911 Center, Blakey Ridge, Beautiful Run	87.8%/88.7	78.6%/79.8%	64.5%/67.8%	31.9%/36.5%

### 10.4.2 Budgetary Cost Estimates – Alternative 2: Madison and Greene Counties to implement a shared System

The estimated costs<sup>29</sup> for Madison County to upgrade the current radio system to a shared P25 Digital Radio System are shown in Table 20 below:

Table 20: Budgetary Cost Estimate - Alternative 2 - Shared P25 Digital Radio System

DESCRIPTION	COST
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<sup>29</sup> Rough order of magnitude

DESCRIPTION	COST
System Infrastructure	\$2,644,000
Master Site System Core	\$325,000
Three Site Fire Paging System (Optional)	\$95,000
Systems Integration, Engineering, and Construction Services	\$1,319,000
IV&D GPS Unit Mapping Option	\$92,000
Madison County Total Shared System Cost	\$4,475,000
Madison County Subscriber Cost	\$862,000
Madison County Total	\$5,337,000

### 10.4.3 Advantage/Disadvantage of Alternative 2

The advantages and disadvantages of Alternative 2 – Madison and Greene Counties to implement a shared P25 Digital Radio System are shown in Table 21 below:

Table 21: Advantages / Disadvantages of Alternative 2

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can be monitored and recorded by Dispatch</li> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the RF simulcast system (Option 2a).</li> <li>• Extended battery operation when compared to analog radios</li> <li>• Alarm and control systems will be in place, which will alert the County when system failures occur. This will</li> </ul>	<ul style="list-style-type: none"> <li>• FCC licensing – requires concurrence from co-channel users</li> <li>• The digital system is susceptible to co-channel interference</li> <li>• County is responsible for capital and recurring cost of RF simulcast system (2a).</li> <li>• Requires new subscriber radios</li> <li>• Higher cost subscriber radios</li> <li>• Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> <li>• Governance and oversight of the shared system</li> </ul>

ADVANTAGES	DISADVANTAGES
<p>facilitate a timely response by the County's maintenance service provider.</p> <ul style="list-style-type: none"> <li>• Availability of P25 Phase 1 pager– P25 Phase 2 is being developed.</li> <li>• Reduced cost of the system due to shared network.</li> <li>• Governance and oversight of the shared system</li> </ul>	

### 10.5 ALTERNATIVE 3 – 3. MADISON AND/OR GREENE COUNTIES TO IMPLEMENT A SHARED, REGIONAL SYSTEM WITH FLUVANNA AND LOUISA COUNTIES

In this option, Madison and Greene counties implement their own RF simulcast sites, each a three-site system and share the existing core switch utilized by Fluvanna and Louisa Counties. The coverage and system capacity is the same as alternative 1.

A variation of this option is to combine the two separate simulcast systems into one and connected to the core switch. This option is similar to Option 2b except it connects to the Fluvanna core switch. A microwave or a leased Ethernet will be required for the connection to Fluvanna core switch. The coverage and system capacity is the same as alternative 2.

#### 10.5.1 Fluvanna and Louisa System

Fluvanna County is in process of implementing a new P25 VHF Digital Trunked Radio System. The coverage design for the county will include seven tower sites and four VHF radio frequencies. When complete, the system will have the capability to add up to seven additional tower sites. This additional capacity will allow Fluvanna County to host Louisa County on the new system. Such an arrangement would provide Louisa County with greatly expanded coverage at a lower cost than would a Louisa standalone P25 system. In addition, because the Fluvanna system will utilize trunking technology, Louisa could realize an increase in system capacity, i.e. the number of talkpaths available to the Louisa users. Because Fluvanna's new system will utilize TDMA technology, Fluvanna's four radio frequencies will result in six talkpaths, similar to having six frequencies in non-TDMA systems.

#### 10.5.2 Coverage Predictions

Coverage for Madison County is same as Alternatives 1 and 2.

### 10.5.3 Budgetary Cost Estimates – Alternative 3: Share the Fluvanna and Louisa Core Switch

The estimated costs<sup>30</sup> for Madison County to upgrade the current radio system to a shared P25 Digital Radio System are shown in Table 22 below:

Table 22: Budgetary Cost Estimate - Alternative 3 - Shared P25 Digital Radio System

DESCRIPTION	COST
System Infrastructure	\$2,644,000
Master Site System Core	\$0
Three Site Fire Paging System (Optional)	\$95,000
Systems Integration, Engineering, and Construction Services	\$1,319,000
IV&D GPS Unit Mapping Option	\$92,000
Madison County Total Shared System Cost	\$4,150,000
Madison County Subscriber Cost	\$862,000
Madison County Total	\$5,012,000

### 10.5.4 Advantage/Disadvantage of Alternative 3

The advantages and disadvantages of Alternative 3 – Madison and/or Greene Counties to implement a shared, regional system with Fluvanna and Louisa Counties are shown in Table 23 below:

Table 23: Advantages / Disadvantages of Alternative 3

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> <li>• Trunked operation</li> <li>• Follows the P25 standards</li> <li>• Digital voice clarity and available encryption</li> <li>• Two talkpaths per channel (2-slot TDMA doubles the channel capacity compared to a 12.5 KHz analog channel)</li> <li>• Federal interoperability guidelines and grant opportunities</li> <li>• Interoperability with neighboring trunked systems such as Albemarle County system through ISSI</li> <li>• Fireground operations will be on the system and can</li> </ul>	<ul style="list-style-type: none"> <li>• FCC licensing – requires concurrence from co-channel users</li> <li>• The digital system is susceptible to co-channel interference</li> <li>• County is responsible for capital and recurring cost of RF simulcast system (3a).</li> <li>• Requires new subscriber radios</li> <li>• Higher cost subscriber radios</li> <li>• Requires maintaining a separate simulcast analog channel for tone and voice fire pagers.</li> <li>• Enhancements to the P25 core switch for applications</li> </ul>

<sup>30</sup> Rough order of magnitude

ADVANTAGES	DISADVANTAGES
<p>be monitored and recorded by Dispatch</p> <ul style="list-style-type: none"> <li>• Agencies in the County can have access to their own talkgroups</li> <li>• Improved mobile and portable coverage within the County through simulcast technology</li> <li>• IP based network</li> <li>• County maintains control of the RF simulcast system (3a).</li> <li>• Extended battery operation when compared to analog radios</li> <li>• Alarm and control systems will be in place, which will alert the County when system failures occur. This will facilitate a timely response by the County's maintenance service provider.</li> <li>• Availability of P25 Phase 1 pager– P25 Phase 2 is being developed.</li> <li>• Reduced cost of the system due to shared network.</li> <li>• Governance and oversight of the shared system</li> </ul>	<p>such as GPS/AVL may require agreements from all parties for cost sharing.</p> <ul style="list-style-type: none"> <li>• Governance and oversight of the shared system</li> </ul>

## 11 NEEDS VS. ALTERNATIVES

The following chart indicates a summary of the needs of Madison County and which of the proposed alternatives meets the specific needs. Alternatives 2 and 3 are the same as Alternative 1 with additional options on sharing the P25 core switch and the RF simulcast system.

Table 24: Needs vs. Alternatives

Need/ Requirement	Alternative 1: Stand-Alone System	Alternative 2: Madison & Greene County Shared System	Alternative 3: Regional System (Madison, Greene, Louisa, Fluvanna)
Improves Radio Coverage	√	√	√
Addresses Channel Congestion	√	√	√
Improves Regional Interoperability with neighboring Agencies	√	√	√
Shares Cost of the Core Switch		√	√
Shares the Cost of the Sites		√ <sup>31</sup>	√ <sup>32</sup>
Autonomy & Control	√		

## 12 CONSULTANT RECOMMENDATION

This report identifies solutions for meeting the needs of the County. The solutions vary from replacing the current system with a standalone P25 system to developing an agreement to operate on neighboring systems. Each has its benefits and disadvantages as discussed previously in this report.

<sup>31</sup> When a common RF simulcast system is used for both counties (Option 2b).

<sup>32</sup> When a common RF simulcast system is used for both counties (Option 3b).

After careful consideration and analysis of each of the three alternatives, the consultant recommends that the Madison County pursue Alternative 2 or 3: Implement a shared system with Greene County and/or share the core switch with Fluvanna/Louisa County 150 MHz Radio System.

## 12.1 NEXT STEPS

The communications solutions will require coordination and consensus of all of the entities to help focus on the best overall solution. In order to identify and successfully implement an effective long-term solution, the following steps are recommended.

- Establish an oversight committee representing public safety communications stakeholders for Madison and Green counties.
- Establish the collective set of requirements for all of the entities represented by the stakeholders.
- Begin discussion and evaluation of governance of a shared P25 system.
- Identify funding sources for implementation of the preferred solution.
- Develop a technical specification and statement of work (SOW). The SOW establishes the requirements for the options discussed in this report.
- Request a proposal from Motorola responding to the SOW.
- Evaluate the proposal received.
- Negotiate a contract for the selected option.

## APPENDIX A: RESPONSES TO QUESTIONNAIRES





## Radio System (Administrator) Questionnaire for Madison County, VA

The information you are providing is very important. The data we are collecting will be used to develop plans for an improved radio system.

### INSTRUCTIONS

Please insert your answers in the shadowed columns in the tables below. If there is a box (☐) , you may click on the appropriate box to enter an X. If the question is not applicable to your organization, you may leave the columns or boxes blank.

### ORGANIZATION INFORMATION

1. Provide the name of the Department / Company / Agency utilizing the radio system you are providing information about.

Department / Company / Agency:	Madison County E-911
Number of Career Personnel:	13
Number of Volunteer Personnel:	0
Your Name and Title:	Robert Finks, 911 Director

2. Provide a brief statement of your Department / Company / Agency's purpose or mission.

Purpose or Mission: To provide 911 service and radio communication for the citizens and agencies of Madison County.

3. Provide a brief statement of your Department / Company / Agency's organizational makeup.

Organizational Makeup: Director, Asst. Director, Dispatchers

4. Provide a brief statement of your Department / Company / Agency's duties.

Duties: To answer emergency calls and dispatch the appropriate agency. To provide dispatching to all emergency service personnel.

5. Provide a brief statement of your Department / Company / Agency's service area.

Service Area: Madison County

6. Describe the radio systems your agency use including radio communications and paging.

Description: VHF Motorola Mototrbo system with VHF analog paging, Low band for sirs



## SYSTEM LOADING

7. List the Vehicles / Apparatus and quantity used by your Department / Company / Agency.

Law Enforcement Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	4
Number of Patrol Vehicles:	15
Number of Investigator Vehicles:	4
Number of Special Unit Vehicles:	1
Number of Command Vehicles:	1
Fire Total Radio Equipped Vehicles:	11
Number of Staff Vehicles:	2
Number of Engines:	2
Number of Trucks:	2
Number of Brush Trucks:	2
Number of Special Unit Vehicles:	2
Number of Command Vehicles:	1
EMS Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	2
Number of Transport Vehicles:	5
Number of Rapid Response Vehicles:	4
Number of Command Vehicles:	4
Schools Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of School Buses:	
Municipal Agency Radio Equipped Vehicles:	
Staff Vehicles:	
Trucks:	
TOTAL NUMBER OF VEHICLES WITH RADIOS:	

8. List the locations and quantity of control station radios (base stations) used by your Department / Company / Agency.

[illegible]





9. Please provide the number / frequency band / manufacturer / model numbers of the radios your Department / Company / Agency uses. (Please include spares and identify which are spares)

	Quantity	Frequency Band (UHF / VHF / 700-800 MHz)	Manufacturer	Model
Example	10	UHF/VHF	Kenwood	NX-300G
Mobiles	10	VHF	Motorola	Mototrbo XPR 4550
Mobiles				
Mobiles				
Mobiles				
Mobiles				
Portables	40	VHF	Motorola	XPR 6550
Portables				
Portables				
Portables				
Portables				
Voice Pagers				
Voice Pagers				
Control Stations	18	VHF	Motorola	XPR 4550
Control Stations				
Control Stations				
Control Stations				
Control Stations				

10. Please provide the estimated percentage of growth in the number of radios estimated over the next 10 years (example: 2%, 3%, 4%, 5%, etc.).

Radio Type	2018	2020	2022	2024	2026	2028
Mobiles	10	10				
Portables	10	10				
Voice Pagers	10	10				
Control Stations	0	0				

## RADIO UTILIZATION

11. Are portable radios assigned to individuals or rotated to various personnel?

Individuals <input checked="" type="checkbox"/>	Rotated <input type="checkbox"/>
---	----------------------------------

12. Are the portable radios taken home after duty hours?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------





Comments:

13. Are portable radios equipped with external speaker microphones?

 Yes ☐

 No ☒

14. Check the box for the type of antenna used.

 3" Stubby ☐

 6" Standard ☐

 Other ☐

Comments:

15. What type of batteries are used on your portable radios?

 NiCad ☐

 Nickel Metal Hydride ☐

 Lithium Ion ☒

16. What is the average age of your portable radio batteries?

 One Year ☒

 Two Years ☐

 More than 2 years ☐

17. When were your portable batteries last replaced?

 1 Year Ago ☒

 2 Years Ago ☐

 3 Years Ago ☐

 More Than 3 Years Ago ☐

18. How long is a typical shift or how many hours do you require your portable batteries to last before needing to be recharged?

 8 hours ☒

 12 hours ☐

 14 hours ☐

 24 hours ☐

Other:

19. Does your agency have a portable battery conditioner analyzer?

 Yes ☒

 No ☐

20. What type of portable battery chargers does your agency use?

 Individual Battery Charger ☐

 Bank Type Gang Charger ☒

21. Does your agency have mobile radios installed in personally owned vehicles?

 Yes ☒

 No ☐

## DAILY OPERATIONS

22. What time of day are your radios used and how many radios are in use per shift?

Shift	Number of Radios in Use by Shift
<input type="checkbox"/> Day	
<input type="checkbox"/> Evening	
<input type="checkbox"/> Night	
<input type="checkbox"/> Any or All	
<input type="checkbox"/> Varies	

23. How many calls did your agency respond to last year?

Number of calls:



24. Are members of your organization issued cell phones?

Yes ☐

No ☒

25. What cellular carrier is used for issued cell phones and how many are issued?

Cell Carrier:

Number of cells phones issued:

26. Are cell phones used to provide communications in areas where radio coverage is weak or non-existent?

Yes ☐

No ☐

27. What areas or your locality are cell phones used where the radio system does not provide communications?

Answer:

## INTEROPERABILITY INFORMATION

28. What other agencies / departments *in your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer: Animal Control, VDOT, VSP, Forestry Service

29. What other agencies / departments *outside of your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer: : Orange County Sheriff, EMS, Fire

Greene County Sheriff, EMS, Fire

Culpeper County Sheriff, EMS, Fire

Rappahannock Sheriff, Fire





30. Does your agency have adequate radio communications capabilities with other agencies?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

31. What agencies do you experience radio communication problems with?

Agencies and describe the problems: ALL

32. What other agencies / departments would you like to be able to have direct radio contact with in the future?

Answer: Culpeper, Orange, Greene, Rappahannock

## COVERAGE REQUIREMENTS

33. Please generally describe the geographic areas where **mobile radio coverage** is typically required for daily operations.

Answer: Madison County

34. Please generally describe the geographic areas where **portable radio coverage** is typically required for daily operations.

Answer: Madison County

35. Is there poor or unreliable radio coverage in areas of your agency's responsibility?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

36. If there are areas of poor radio coverage, describe the approximate locations. Please provide street names, hundred blocks, cross streets, or landmarks. Please include any building names and street addresses your have experienced poor radio coverage. Also describe the coverage as poor, occasional, or no coverage. Please state if the poor coverage is transmit or receive.

Answer:





## FUTURE SYSTEM GOALS

37. Please provide the requirements for radio and radio system features desired or required by your agency.

Features	Desired	Required
Emergency Alert with ID Display	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Unit ID on Transmissions	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Individual Call Capability	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Telephone Interconnect	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Voice Encryption	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
GPS Operation	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Multi-Band Operation	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Text Messaging	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Integrated Voice and Data	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Advanced Software	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Other (Identify/Explain below)	Desired <input type="checkbox"/>	Required <input type="checkbox"/>

38. Please list other radio or radio system features your agency would desire or require in a new radio system. If you listed any features above as required, please give an explanation, reason or an example of a use for the feature.

Answer:

## CURRENT RADIO SYSTEM CONCERNS OR PROBLEMS

Please identify any problems you are currently experiencing with your existing radio system:

39. Does your radio system have too many radios sharing a channel or channels?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

40. What is the more common causes or times when there is channel congestion?

Answer: People trying to talk at same time

41. How often does channel congestion occur?

Frequently <input checked="" type="checkbox"/>	Occasionally <input type="checkbox"/>	Never <input type="checkbox"/>
--	---------------------------------------	--------------------------------

42. If channel congestion occurs, how long does it take to get a clear channel to communicate? Please provide your comments and provide examples.

Answer:





43. Does your radio system experience interference from other entities?

Frequently ☐

Occasionally ☒

Never ☐

44. Please reference street names and cross streets or other location information if possible for clarification. In the comments section below, if known, list the other interfering entities and/or describe the interference.

Interference locations and interfering entities if know:

45. Does your agency use outdated radio equipment (Portables over 5-7 years old, mobiles over 10 years old)?

Yes ☐

No ☒

46. Please describe the age and general condition of your radios:

Describe radios: good condition, 6 years old

47. Does your agency experience frequent portable or mobile radio failures?

Yes ☒

No ☐

48. Please describe the types of failures your agency experiences or make comments.

Types of radio failures or comments:

49. How long do portable and mobile radio repairs take to complete?

Comment:

50. Who is responsible for your radio repair / service?

Comment: Clear Communications

51. Do major portions of your radio system or the entire radio system fail and how long does it take to recover from the failure?

Yes ☐

No ☐

For How Long:

52. Please provide any additional information regarding your Department's radio operations you believe would be of interest and/or value in relation to this study.

Comments:





53. In your opinion the next radio communications system should be (please explain in as much detail as possible and give reasons why):

Comments: Trunked VHF Simulcast P25 system




## DISPATCH OPERATIONS

54. Please provide the name and location of your fixed dispatch points (Communications Centers, PSAP, Back-up Dispatch Center, etc.)

Name	Street Address	City/Town/Zip Code	Contact Name
Madison County E-911	107 Church St	Madison, VA	Robert Finks
Orange County 911		Orange, VA	Nikey Tidey

55. Please provide the type, location, and quantity of your fixed dispatch equipment.

To assist you in identifying the type, refer to the table below:

Type 1 – Multi-Channel Radio Consoles		
Type 2 – Multi-Channel Desktop Consoles		
Type 3 – Control Stations with Desktop Microphone		
Type	Location	Quantity
<b>1</b>	<b>107 Church St</b>	<b>4</b>





Type	Location	Quantity

56. Where are your Base Station / Repeater Tower Sites located?

Site Name	Tower Height	Street Address	City/Town /Zip Code	Tower Owner / Lease From
911 Center		107 Church St	Madison, VA 22727	Own
Blakey Ridge		Blakey Ridge	Aylor, VA 22727	Own
Beautiful Run Rd	99 ft		Radiant, VA	Lease
WFS			Woodberry Forest, VA	Free

## CURRENT SYSTEM CHANNELS

57. Please list all frequencies now used in the current system and describe what each is used for. Please attach copies of FCC licenses if available.

Frequency	Used For	Channel Name	Call Sign
Example:			
155.250	Sheriff Dispatch	SO Dispatch	QBX323
155.235	Helicopter LZ	Rescue Simplex	KKL921
Rx155.385 / Tx154.070	Rescue Operations	Rescue 1	KKL921
Rx155.385 / Tx154.070	Rescue Operations	Rescue 2	KKL921
Rx154.355 / Tx159.045	Fire Operations	Fire 1	WPJP622
Rx154.355 / Tx159.045	Fire Operations	Fire 2	WPJP622
154.265	Fire to Fire	Fire Tac	WPJP622
Rx154.800 / Tx155.730	Sheriff Operations	Sheriff 1	WPJU625
Rx154.800 / Tx155.730	Sheriff Operations	Sheriff 2	WPJU625
156.030	Sheriff to Sheriff	Sheriff Tac	WPJU625
Rx151.1675/Tx158.7525	Voting and Other	Public Works	WQOG368
Rx151.325 / Tx156.210	Spare	County 1	WQOG368
Rx151.325 / Tx156.210	Spare	County 2	WQOG368
154.430	Paging and Mutual Aid	Paging	WPJP622

Printed Name:

Department / Agency:

Division:

Title:

Contact Phone  
Number:

Email Address:

Please return the completed questionnaire with attachments to:

Robert Finks  
Emergency Coordinator / 911 Director  
Madison County, VA  
Office: (540) 948-5144



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If you have any questions regarding this questionnaire, please contact:

Cell: (540) 718-0474

Email: [rfinks@madisoncom.virginia.gov](mailto:rfinks@madisoncom.virginia.gov)

David Gelyana

Black & Veatch

Office: (312) 683-7811

Email: [gelyanad@bv.com](mailto:gelyanad@bv.com)

Or

Don Bowman

Black & Veatch

Office: (919) 463-3034

Email: [BowmanD2@bv.com](mailto:BowmanD2@bv.com)

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## Radio System (Users) Questionnaire for Madison County, VA

The information you are providing is very important. The data we are collecting will be used to develop plans for an improved radio system.

### INSTRUCTIONS

Please insert your answers in the shadowed columns in the tables below. If there is a box (☐) , you may click on the appropriate box to enter an X. If the question is not applicable to your organization, you may leave the columns or boxes blank.

### ORGANIZATION INFORMATION

1. Provide the name of the Department / Company / Agency utilizing the radio system you are providing information about.

Department / Company / Agency:	Madison County Sheriff's Office
Number of Career Personnel:	28
Number of Volunteer Personnel:	0
Your Name and Title:	Erik J. Weaver, Sheriff

2. Provide a brief statement of your Department / Company / Agency's purpose or mission.

Purpose or Mission: The mission of the MCSO is to enhance the quality of life by providing law enforcement services through shared responsibility with the public.

3. Provide a brief statement of your Department / Company / Agency's organizational makeup.

Organizational Makeup: Establish and maintain good relations with citizens and to set guidelines for the department personnel involving contacts with the public.

4. Provide a brief statement of your Department / Company / Agency's duties.

Duties:

5. Provide a brief statement of your Department / Company / Agency's service area.

Service Area: 347 square miles

6. Describe the radio systems your agency use including radio communications and paging.

Description: VHF Mototurbo, Sirs

7. List the Vehicles / Apparatus and quantity used by your Department / Company / Agency.

Law Enforcement Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	3
Number of Patrol Vehicles:	20
Number of Investigator Vehicles:	4
Number of Special Unit Vehicles:	5
Number of Command Vehicles:	2
Fire Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Engines:	
Number of Trucks:	
Number of Brush Trucks:	
Number of Special Unit Vehicles:	
Number of Command Vehicles:	
EMS Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Transport Vehicles:	
Number of Rapid Response Vehicles:	
Number of Command Vehicles:	
Schools Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of School Buses:	
Municipal Agency Radio Equipped Vehicles:	
Staff Vehicles:	
Trucks:	
TOTAL NUMBER OF VEHICLES WITH RADIOS:	

[illegible]




9. Please provide the number / frequency band / manufacturer / model numbers of the radios your Department / Company / Agency uses. (Please include spares)

	Quantity	Frequency Band (UHF / VHF / 700-800 MHz)	Manufacturer	Model
Example	10	UHF/VHF	Kenwood	NX-300G
Mobiles	33		Motorola	XPR4550
Mobiles				
Mobiles				
Mobiles				
Mobiles				
Portables	37		Motorola	XPR6550
Portables				
Portables				
Portables				
Portables				
Voice Pagers				
Voice Pagers				
Control Stations				
Control Stations				
Control Stations				
Control Stations				
Control Stations				

10. Please provide the estimated percentage of growth in the number of radios estimated over the next 10 years (example: 2%, 3%, 4%, 5%, etc.).

Radio Type	2018	2020	2022	2024	2026	2028
Mobiles	5	5				
Portables	5	5				
Voice Pagers						
Control Stations						

## RADIO UTILIZATION

11. Are portable radios assigned to individuals or rotated to various personnel?

Individuals <input checked="" type="checkbox"/>	Rotated <input type="checkbox"/>
---	----------------------------------

12. Are the portable radios taken home after duty hours?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

Comments:

13. Are portable radios equipped with external speaker microphones?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

14. Check the box for the type of antenna used.

3" Stubby <input type="checkbox"/>	6" Standard <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
Comments:		

15. What type of batteries are used on your portable radios?

NiCad <input type="checkbox"/>	Nickel Metal Hydride <input type="checkbox"/>	Lithium Ion <input checked="" type="checkbox"/>
--------------------------------	---	---

16. What is the average age of your portable radio batteries?

One Year <input type="checkbox"/>	Two Years <input checked="" type="checkbox"/>	More than 2 years <input type="checkbox"/>
-----------------------------------	---	--

17. When were your portable batteries last replaced?

1 Year Ago <input checked="" type="checkbox"/>	2 Years Ago <input type="checkbox"/>	3 Years Ago <input type="checkbox"/>	More Than 3 Years Ago <input type="checkbox"/>
--	--------------------------------------	--------------------------------------	--

18. How long is a typical shift or how many hours do you require your portable batteries to last before needing to be recharged?

8 hours <input type="checkbox"/>	12 hours <input checked="" type="checkbox"/>	14 hours <input type="checkbox"/>	24 hours <input type="checkbox"/>	Other:
----------------------------------	--	-----------------------------------	-----------------------------------	--------

19. Does your agency have a portable battery conditioner analyzer?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

20. What type of portable battery chargers does your agency use?

Individual Battery Charger <input checked="" type="checkbox"/>	Bank Type Gang Charger <input type="checkbox"/>
--	---

21. Does your agency have mobile radios installed in personally owned vehicles?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

## DAILY OPERATIONS

22. What time of day are your radios used and how many radios are in use per shift?

Shift	Number of Radios in Use by Shift
<input checked="" type="checkbox"/> Day	
<input checked="" type="checkbox"/> Evening	
<input checked="" type="checkbox"/> Night	
<input checked="" type="checkbox"/> Any or All	14 - 16
<input checked="" type="checkbox"/> Varies	

23. How many calls did your agency respond to last year?

Number of calls: 12358

24. Are members of your organization issued cell phones?

Yes ☒

No ☐

25. What cellular carrier is used for issued cell phones and how many are issued?

Cell Carrier: Verizon

Number of cells phones issued: 7 +

26. Are cell phones used to provide communications in areas where radio coverage is weak or non-existent?

Yes ☒

No ☐

27. What areas or your locality are cell phones used where the radio system does not provide communications?

Answer: (rural areas) Greater distance from cell towers

## INTEROPERABILITY INFORMATION

28. What other agencies / departments *in your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer:

Fire, Rescue, VDOT, Game Commission, Common Channel, Different Radios

29. What other agencies / departments *outside of your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer:

VSP, Portables

30. Does your agency have adequate radio communications capabilities with other agencies?



Yes ☐No ☒

31. What agencies do you experience radio communication problems with?

Agencies and describe the problems: ALL (hit or miss, tower coverage, communications

32. What other agencies / departments would you like to be able to have direct radio contact with in the future?

Answer:

Greene, Orange, Culpeper, Rappahannock

## COVERAGE REQUIREMENTS

33. Please generally describe the geographic areas where **mobile radio coverage** is typically required for daily operations.

Answer:

Entire County

34. Please generally describe the geographic areas where **portable radio coverage** is typically required for daily operations.

Answer:

Entire County

35. Is there poor or unreliable radio coverage in areas of your agency's responsibility?

Yes ☒No ☐

36. If there are areas of poor radio coverage, describe the approximate locations. Please provide street names, hundred blocks, cross streets, or landmarks. Please include any building names and street addresses your have experienced poor radio coverage. Also describe the coverage as poor, occasional, or no coverage. Please state if the poor coverage is transmit or receive.

Answer:

Entire County - transmit and receive

## FUTURE SYSTEM GOALS

37. Please provide the requirements for radio and radio system features desired or required by your agency.

Features	Desired	Required
Emergency Alert with ID Display	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Unit ID on Transmissions	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Individual Call Capability	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Telephone Interconnect	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Voice Encryption	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
GPS Operation	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Multi-Band Operation	Desired <input type="checkbox"/>	Required <input checked="" type="checkbox"/>
Text Messaging	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Integrated Voice and Data	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Advanced Software	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Other (Identify/Explain below)	Desired <input type="checkbox"/>	Required <input type="checkbox"/>

38. Please list other radio or radio system features your agency would desire or require in a new radio system. If you listed any features above as required, please give an explanation, reason or an example of a use for the feature.

Answer:

## CURRENT RADIO SYSTEM CONCERNS OR PROBLEMS

Please identify any problems you are currently experiencing with your existing radio system:

39. Does your radio system have too many radios sharing a channel or channels?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

40. What are the more common causes or times when there is channel congestion?

Answer: events with multi radios at one location causing system to shut down.

41. How often does channel congestion occur?

Frequently <input checked="" type="checkbox"/>	Occasionally <input type="checkbox"/>	Never <input type="checkbox"/>
--	---------------------------------------	--------------------------------

42. If channel congestion occurs, how long does it take to get a clear channel to communicate? Please provide your comments and provide examples.

Answer:

Several minutes, multiple radios at one location

43. Does your radio system experience interference from other entities?

Frequently <input type="checkbox"/>	Occasionally <input checked="" type="checkbox"/>	Never <input type="checkbox"/>
-------------------------------------	--	--------------------------------

44. Please reference street names and cross streets or other location information if possible for clarification. In the comments section below, if known, list the other interfering entities and/or describe the interference.

Interference locations and interfering entities if know:  
Entire County

45. Does your agency use outdated radio equipment (Portables over 5-7 years old, mobiles over 10 years old)?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

46. Please describe the age and general condition of your radios:

Describe radios: 2 – 5 years old but in good condition

47. Does your agency experience frequent portable or mobile radio failures?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

48. Please describe the types of failures your agency experiences or make comments.

Types of radio failures or comments:  
Multiple radios at one location not able to communication on mobile or portable.

49. How long do portable and mobile radio repairs take to complete?

Comment: 2-4 weeks

50. Who is responsible for your radio repair / service?

Comment: Clear Communications/Motorola

51. Do major portions of your radio system or the entire radio system fail and how long does it take to recover from the failure?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	For How Long: 5-15 minutes
---	-----------------------------	----------------------------

52. Please provide any additional information regarding your Department's radio operations you believe would be of interest and/or value in relation to this study.

Comments:

Previously stated above.

53. In your opinion the next radio communications system should be (please explain in as much detail as possible and give reasons why):

Comments:

See Radar's Comments

Printed Name:	Erik J. Weaver	Title:	Sheriff
Department / Agency:	Madison Co Sheriffs Office	Contact Phone Number:	540.948.5161
Division:		Email Address:	mcsheriff@madisonco.virginia.gov

Please return the completed questionnaire with attachments to:

Robert Finks  
Emergency Coordinator / 911 Director  
Madison County, VA  
Office: (540) 948-5144  
Cell: (540) 718-0474  
Email: [rfinks@madisonco.virginia.gov](mailto:rfinks@madisonco.virginia.gov)

If you have any questions regarding this questionnaire, please contact:

David Gelyana  
Black & Veatch  
Office: (312) 683-7811  
Email: [gelyanad@bv.com](mailto:gelyanad@bv.com)  
Or  
Don Bowman  
Black & Veatch  
Office: (919) 463-3034  
Email: [BowmanD2@bv.com](mailto:BowmanD2@bv.com)

## Radio System (Users) Questionnaire for Madison County, VA

The information you are providing is very important. The data we are collecting will be used to develop plans for an improved radio system.

### INSTRUCTIONS

Please insert your answers in the shadowed columns in the tables below. If there is a box (☐) , you may click on the appropriate box to enter an X. If the question is not applicable to your organization, you may leave the columns or boxes blank.

### ORGANIZATION INFORMATION

1. Provide the name of the Department / Company / Agency utilizing the radio system you are providing information about.

Department / Company / Agency:	Madison EMS
Number of Career Personnel:	16 full-time, 12 part-time
Number of Volunteer Personnel:	MCRS should provide
Your Name and Title:	Lewis P. Jenkins, EMS Director

2. Provide a brief statement of your Department / Company / Agency's purpose or mission.

Purpose or Mission:
To provide Emergency Medical Services

3. Provide a brief statement of your Department / Company / Agency's organizational makeup.

Organizational Makeup: Director, 2 FT Lieutenants, 13 EMT-I and EMT-P.
--

4. Provide a brief statement of your Department / Company / Agency's duties.

Duties: Respond to EMS calls
------------------------------

5. Provide a brief statement of your Department / Company / Agency's service area.

Service Area: Madison County's rural and mountainous terrain.
---

6. Describe the radio systems your agency use including radio communications and paging.

Description: Mobile radios, portable radios and pagers provided by the County
---

### SYSTEM LOADING

7. List the Vehicles / Apparatus and quantity used by your Department / Company / Agency.

Law Enforcement Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Patrol Vehicles:	
Number of Investigator Vehicles:	

Number of Special Unit Vehicles:	
Number of Command Vehicles:	
Fire Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Engines:	
Number of Trucks:	
Number of Brush Trucks:	
Number of Special Unit Vehicles:	
Number of Command Vehicles:	
EMS Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Transport Vehicles:	
Number of Rapid Response Vehicles:	2
Number of Command Vehicles:	1 MCI van
Schools Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of School Buses:	
Municipal Agency Radio Equipped Vehicles:	
Staff Vehicles:	
Trucks:	
<b>TOTAL NUMBER OF VEHICLES WITH RADIOS:</b>	

8. List the locations and quantity of control station radios (base stations) used by your Department / Company / Agency.

Locations	Number of Control Stations (Base Stations)
See County system	

9. Please provide the number / frequency band / manufacturer / model numbers of the radios your Department / Company / Agency uses. (Please include spares)

	Quantity	Frequency Band (UHF / VHF / 700-800 MHz)	Manufacturer	Model
Example	10	UHF/VHF	Kenwood	NX-300G

Mobiles	5	VHF	MOTOROLA	XPR4550
Mobiles				
Mobiles				
Mobiles				
Mobiles				
Portables	11	VHF	MOTOROLA	XPR6550
Portables	2	VHF	MOROROLA	HT1250
Portables				
Portables				
Portables				
Voice Pagers	11	VHF	MOTOROLA	MINITOR V
Voice Pagers	1	VHF	MOTOROLA	MINITOR VI
Control Stations				
Control Stations				
Control Stations				
Control Stations				
Control Stations				

10. Please provide the estimated percentage of growth in the number of radios estimated over the next 10 years (example: 2%, 3%, 4%, 5%, etc.).

Radio Type	2018	2020	2022	2024	2026	2028
Mobiles			20%			
Portables			20%			
Voice Pagers			20%			
Control Stations						

## RADIO UTILIZATION

11. Are portable radios assigned to individuals or rotated to various personnel?

Individuals <input type="checkbox"/>	Rotated <input type="checkbox"/>
--------------------------------------	----------------------------------

12. Are the portable radios taken home after duty hours?

Yes <input type="checkbox"/>	No <input type="checkbox"/>
------------------------------	-----------------------------

Comments: (4 ASSIGNED, OTHERS ROTATED)

13. Are portable radios equipped with external speaker microphones? 7 AVAILABLE, BUT NOT USED BY EVERYONE

Yes X <input type="checkbox"/>	No X <input type="checkbox"/>
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14. Check the box for the type of antenna used.

3" Stubby <input type="checkbox"/>	6" Standard X <input type="checkbox"/>	Other <input type="checkbox"/>
Comments:		

15. What type of batteries are used on your portable radios?

NiCad <input type="checkbox"/>	Nickel Metal Hydride <input type="checkbox"/>	Lithium Ion X <input type="checkbox"/>
--------------------------------	---	--

16. What is the average age of your portable radio batteries?

One Year <input type="checkbox"/>	Two Years X <input type="checkbox"/>	More than 2 years <input type="checkbox"/>
-----------------------------------	--------------------------------------	--

17. When were your portable batteries last replaced? As needed, when radio has <70% service life.

1 Year Ago <input type="checkbox"/>	2 Years Ago <input type="checkbox"/>	3 Years Ago <input type="checkbox"/>	More Than 3 Years Ago <input type="checkbox"/>
-------------------------------------	--------------------------------------	--------------------------------------	--

18. How long is a typical shift or how many hours do you require your portable batteries to last before needing to be recharged?

8 hours <input type="checkbox"/>	12 hours <input type="checkbox"/>	14 hours x <input type="checkbox"/>	24 hours <input type="checkbox"/>	Other:
----------------------------------	-----------------------------------	-------------------------------------	-----------------------------------	--------

19. Does your agency have a portable battery conditioner analyzer?

Yes x <input type="checkbox"/>	No <input type="checkbox"/>
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20. What type of portable battery chargers does your agency use?

Individual Battery Charger x <input type="checkbox"/>	Bank Type Gang Charger x <input type="checkbox"/>
---	---

21. Does your agency have mobile radios installed in personally owned vehicles?

Yes <input type="checkbox"/>	No x <input type="checkbox"/>
------------------------------	-------------------------------

## DAILY OPERATIONS

22. What time of day are your radios used and how many radios are in use per shift?

Shift	Number of Radios in Use by Shift
<input type="checkbox"/> Day	10
<input type="checkbox"/> Evening	10
<input type="checkbox"/> Night	2
<input type="checkbox"/> Any or All	
<input type="checkbox"/> Varies	

23. How many calls did your agency respond to last year?

Number of calls: 1300+
------------------------

24. Are members of your organization issued cell phones? Director and 1 LT.

Yes x <input type="checkbox"/>	No <input type="checkbox"/>
--------------------------------	-----------------------------



25. What cellular carrier is used for issued cell phones and how many are issued?

Cell Carrier: Verizon	Number of cells phones issued: 2

26. Are cell phones used to provide communications in areas where radio coverage is weak or non-existent?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

27. What areas or your locality are cell phones used where the radio system does not provide communications?

Answer:

Radio has a larger coverage area than the cell phones

## INTEROPERABILITY INFORMATION

28. What other agencies / departments **in your locality** do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer:

Dispatch on rescue 1. Fire on fire 1.

29. What other agencies / departments **outside of your locality** do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer:

UVa, Culpeper, Martha Jefferson main and Free Standing hospitals on 155.340

Pegasus and PHI aircare helicopters on simplex 155.235

Orange and Greene Counties on their main freq.

Culpeper and Rapp. Counties require a patch or them switching to simplex

Shen. Park service ? simplex will work when we are close.

30. Does your agency have adequate radio communications capabilities with other agencies?

Yes ☐

No ☒

31. What agencies do you experience radio communication problems with?

Agencies and describe the problems:  
Madison Dispatch is most frequent.

Culpeper Co. , Rapp. Co. and SNP

32. What other agencies / departments would you like to be able to have direct radio contact with in the future?

Answer:

All surrounding agencies

## COVERAGE REQUIREMENTS

33. Please generally describe the geographic areas where **mobile radio coverage** is typically required for daily operations.

Answer:

Madison County and the area between UVa, MJH and Culpeper.

34. Please generally describe the geographic areas where **portable radio coverage** is typically required for daily operations.

Answer:

Within the County

35. Is there poor or unreliable radio coverage in areas of your agency's responsibility?

Yes ☒

No ☐

36. If there are areas of poor radio coverage, describe the approximate locations. Please provide street names, hundred blocks, cross streets, or landmarks. Please include any building names and street

addresses your have experienced poor radio coverage. Also describe the coverage as poor, occasional, or no coverage. Please state if the poor coverage is transmit or receive.

Answer:

Mobile coverage is good as long as the correct towers are selected. We have a few dead spots near the Blue Ridge mountains. Portable coverage is fair. There are multiple locations that we are not able to transmit clearly.

## FUTURE SYSTEM GOALS

37. Please provide the requirements for radio and radio system features desired or required by your agency.

Features	Desired	Required
Emergency Alert with ID Display	Desired <input type="checkbox"/>	Required x <input type="checkbox"/>
Unit ID on Transmissions	Desired <input type="checkbox"/>	Required x <input type="checkbox"/>
Individual Call Capability	Desired x <input type="checkbox"/>	Required <input type="checkbox"/>
Telephone Interconnect	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Voice Encryption	Desired x <input type="checkbox"/>	Required <input type="checkbox"/>
GPS Operation	Desired <input type="checkbox"/>	Required x <input type="checkbox"/>
Multi-Band Operation	Desired x <input type="checkbox"/>	Required <input type="checkbox"/>
Text Messaging	Desired <input type="checkbox"/>	Required x <input type="checkbox"/>
Integrated Voice and Data	Desired x <input type="checkbox"/>	Required <input type="checkbox"/>
Advanced Software	Desired x <input type="checkbox"/>	Required <input type="checkbox"/>
Other (Identify/Explain below)	Desired <input type="checkbox"/>	Required <input type="checkbox"/>

38. Please list other radio or radio system features your agency would desire or require in a new radio system. If you listed any features above as required, please give an explanation, reason or an example of a use for the feature.

Answer: More interoperability with CAD system.

## CURRENT RADIO SYSTEM CONCERNS OR PROBLEMS

Please identify any problems you are currently experiencing with your existing radio system:

39. Does you radio system have too many radios sharing a channel or channels?

Yes x <input type="checkbox"/>	No <input type="checkbox"/>
--------------------------------	-----------------------------

40. What is the more common causes or times when there is channel congestion?

Answer: high call volume, MVC calls, severe weather increasing calls (ice, snow, high winds)

41. How often does channel congestion occur?

Frequently ☐Occasionally x☐Never ☐

42. If channel congestion occurs, how long does it take to get a clear channel to communicate? Please provide your comments and provide examples.

Answer:

Varies, can be several minutes

43. Does your radio system experience interference from other entities?

Frequently x☐Occasionally ☐Never ☐

44. Please reference street names and cross streets or other location information if possible for clarification. In the comments section below, if known, list the other interfering entities and/or describe the interference.

Interference locations and interfering entities if know:

Richmond area on paging channel

45. Does your agency use outdated radio equipment (Portables over 5-7 years old, mobiles over 10 years old)?

Yes x☐No ☐

46. Please describe the age and general condition of your radios:

Describe radios:

I'm not sure of exact age of our system – Robert Finks

47. Does your agency experience frequent portable or mobile radio failures?

Yes ☐No x☐

48. Please describe the types of failures your agency experiences or make comments.

Types of radio failures or comments:

Not able to transmit or receive with dispatch

49. How long do portable and mobile radio repairs take to complete?

Comment:

Unsure, not tracked. Best guess is over 1 week.

50. Who is responsible for your radio repair / service?

Comment: Taken to Clear Communications

51. Do major portions of your radio system or the entire radio system fail and how long does it take to recover from the failure?

Yes x☐No ☐

For How Long: quickly fixed, not

tracked, maybe &lt;12 hours

52. Please provide any additional information regarding your Department's radio operations you believe would be of interest and/or value in relation to this study.

Comments:

I would like to see a system that could use more data and less voice. For example, the address and patient information appearing in text format. Something similar to the Active911 over the radio system.

53. In your opinion the next radio communications system should be (please explain in as much detail as possible and give reasons why):

Comments:

I believe we need to meet the P25 requirements.

Printed Name:

Lewis Jenkins

Title:

EMS Director

Department /  
Agency:

Madison County

Contact Phone  
Number:

540-948-4813

Division:

Email Address:

[ljenkins@madisonco.virginia.gov](mailto:ljenkins@madisonco.virginia.gov)

Please return the completed questionnaire with attachments to:

Robert Finks  
Emergency Coordinator / 911 Director  
Madison County, VA  
Office: (540) 948-5144  
Cell: (540) 718-0474  
Email: [rfinks@madisonco.virginia.gov](mailto:rfinks@madisonco.virginia.gov)

If you have any questions regarding this questionnaire, please contact:

David Gelyana  
Black & Veatch  
Office: (312) 683-7811  
Email: [gelyanad@bv.com](mailto:gelyanad@bv.com)  
Or  
Don Bowman  
Black & Veatch  
Office: (919) 463-3034  
Email: [BowmanD2@bv.com](mailto:BowmanD2@bv.com)

## Radio System (Users) Questionnaire for Madison County, VA

The information you are providing is very important. The data we are collecting will be used to develop plans for an improved radio system.

### INSTRUCTIONS

Please insert your answers in the shadowed columns in the tables below. If there is a box (☐) , you may click on the appropriate box to enter an X. If the question is not applicable to your organization, you may leave the columns or boxes blank.

### ORGANIZATION INFORMATION

1. Provide the name of the Department / Company / Agency utilizing the radio system you are providing information about.

Department / Company / Agency:	Madison County Vol. Fire Co., Inc.
Number of Career Personnel:	0
Number of Volunteer Personnel:	
Your Name and Title:	Troy Copping, Chief

2. Provide a brief statement of your Department / Company / Agency's purpose or mission.

Purpose or Mission: The preservation and protection of life and property from and during such fires as may occur in the County of Madison, Virginia, and to assist any neighboring fire company upon their request.

3. Provide a brief statement of your Department / Company / Agency's organizational makeup.

Organizational Makeup: We are a 100% volunteer organization, led by administrative and line officers. The administrative officers oversee all non-emergency operations of the department, while the line officers command all emergency operations and equipment.

4. Provide a brief statement of your Department / Company / Agency's duties.

Duties: We provide fire protection, prevention, and education to Madison County. Additionally we provide assistance to MCRS/MEMS providing extrication and other duties as needed. We also assist the MSCO and VSP as needed with traffic control.

5. Provide a brief statement of your Department / Company / Agency's service area.

Service Area: The entire county of Madison, and the surrounding area as requested and available.

6. Describe the radio systems your agency use including radio communications and paging.

Description: We currently have approximately 12 mobile radios, 45 portable radios, and 65 pagers in service.

7. List the Vehicles / Apparatus and quantity used by your Department / Company / Agency.

8. List the locations and quantity of control station radios (base stations) used by your Department / Company / Agency.

2 of 9

9. Please provide the number / frequency band / manufacturer / model numbers of the radios your Department / Company / Agency uses. (Please include spares)

	Quantity	Frequency Band (UHF / VHF / 700-800 MHz)	Manufacturer	Model
Example	10	UHF/VHF	Kenwood	NX-300G
Mobiles	9	VHF	Motorola	
Mobiles				
Mobiles				
Mobiles				
Mobiles				
Portables	35	VHF	Motorola	XPR-6550
Portables	5	VHF	Motorola	XPR-7550e
Portables				
Portables				
Portables				
Voice Pagers				
Voice Pagers				
Control Stations				
Control Stations				
Control Stations				
Control Stations				
Control Stations				

10. Please provide the estimated percentage of growth in the number of radios estimated over the next 10 years (example: 2%, 3%, 4%, 5%, etc.).

Radio Type	2018	2020	2022	2024	2026	2028
Mobiles	0%	0%	0%	10%	0%	0%
Portables	0%	0%	0%	0%	0%	0%
Voice Pagers	5%	5%	5%	5%	5%	5%
Control Stations						

## RADIO UTILIZATION

11. Are portable radios assigned to individuals or rotated to various personnel?

Individuals <input checked="" type="checkbox"/>	Rotated <input type="checkbox"/>
---	----------------------------------

12. Are the portable radios taken home after duty hours?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------



Comments:

13. Are portable radios equipped with external speaker microphones?

Yes ☐

No ☒

14. Check the box for the type of antenna used.

3" Stubby ☐

6" Standard ☒

Other ☐

Comments:

15. What type of batteries are used on your portable radios?

NiCad ☐

Nickel Metal Hydride ☐

Lithium Ion ☒

16. What is the average age of your portable radio batteries?

One Year ☐

Two Years ☒

More than 2 years ☐

17. When were your portable batteries last replaced?

1 Year Ago ☐

2 Years Ago ☒

3 Years Ago ☐

More Than 3 Years Ago ☐

18. How long is a typical shift or how many hours do you require your portable batteries to last before needing to be recharged?

8 hours ☐

12 hours ☐

14 hours ☒

24 hours ☐

Other:

19. Does your agency have a portable battery conditioner analyzer?

Yes ☐

No ☒

20. What type of portable battery chargers does your agency use?

Individual Battery Charger ☒

Bank Type Gang Charger ☐

21. Does your agency have mobile radios installed in personally owned vehicles?

Yes ☒

No ☐

## DAILY OPERATIONS

22. What time of day are your radios used and how many radios are in use per shift?

Shift	Number of Radios in Use by Shift
<input type="checkbox"/> Day	All hours of the day and number fluctuates depending on volume
<input type="checkbox"/> Evening	
<input type="checkbox"/> Night	
<input type="checkbox"/> Any or All	
<input type="checkbox"/> Varies	

23. How many calls did your agency respond to last year?

Number of calls: 383

24. Are members of your organization issued cell phones?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

25. What cellular carrier is used for issued cell phones and how many are issued?

Cell Carrier:	Number of cells phones issued:
---------------	--------------------------------

26. Are cell phones used to provide communications in areas where radio coverage is weak or non-existent?

Yes <input type="checkbox"/>	No <input type="checkbox"/>
------------------------------	-----------------------------

27. What areas or your locality are cell phones used where the radio system does not provide communications?

Answer: Many of the areas where radio coverage is weak, are also areas where cell phone coverage is weak also.

## INTEROPERABILITY INFORMATION

28. What other agencies / departments *in your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer: MSCO, MCRS and MEMS through common channels

29. What other agencies / departments *outside of your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer: Culpeper County fire and Rappahannock County fire through different radio.

Orange County and Greene County through common channel.

30. Does your agency have adequate radio communications capabilities with other agencies?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

31. What agencies do you experience radio communication problems with?

Agencies and describe the problems: Any and all are problematic at times, due to poor reception in certain areas, and having to use 2 different radios when working with certain counties.

32. What other agencies / departments would you like to be able to have direct radio contact with in the future?

Answer: In a perfect world all surrounding jurisdictions

## COVERAGE REQUIREMENTS

33. Please generally describe the geographic areas where *mobile radio coverage* is typically required for daily operations.

Answer: All of Madison County

34. Please generally describe the geographic areas where *portable radio coverage* is typically required for daily operations.

Answer: All of Madison County

35. Is there poor or unreliable radio coverage in areas of your agency's responsibility?

Yes ☒

No ☐

36. If there are areas of poor radio coverage, describe the approximate locations. Please provide street names, hundred blocks, cross streets, or landmarks. Please include any building names and street addresses your have experienced poor radio coverage. Also describe the coverage as poor, occasional, or no coverage. Please state if the poor coverage is transmit or receive.

Answer: South Seminole Trail between south Main St. and the 1700 Block (Transmit), many areas with terrain issues (Both Transmit and Receive), Extreme South End of the County (Transmit), Extreme Western Side of the County Transmit/Receive,.

## FUTURE SYSTEM GOALS

37. Please provide the requirements for radio and radio system features desired or required by your agency.

Features	Desired	Required
----------	---------	----------

Emergency Alert with ID Display	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Unit ID on Transmissions	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Individual Call Capability	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Telephone Interconnect	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Voice Encryption	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
GPS Operation	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Multi-Band Operation	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Text Messaging	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Integrated Voice and Data	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Advanced Software	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Other (Identify/Explain below)	Desired <input type="checkbox"/>	Required <input type="checkbox"/>

38. Please list other radio or radio system features your agency would desire or require in a new radio system. If you listed any features above as required, please give an explanation, reason or an example of a use for the feature.

Answer:

## CURRENT RADIO SYSTEM CONCERNS OR PROBLEMS

Please identify any problems you are currently experiencing with your existing radio system:

39. Does your radio system have too many radios sharing a channel or channels?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

40. What is the more common causes or times when there is channel congestion?

Answer: Large scale incidents, weather, location

41. How often does channel congestion occur?

Frequently <input type="checkbox"/>	Occasionally <input checked="" type="checkbox"/>	Never <input type="checkbox"/>
-------------------------------------	--	--------------------------------

42. If channel congestion occurs, how long does it take to get a clear channel to communicate? Please provide your comments and provide examples.

Answer: 15 – 30 seconds generally

43. Does your radio system experience interference from other entities?

Frequently <input type="checkbox"/>	Occasionally <input type="checkbox"/>	Never <input checked="" type="checkbox"/>
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44. Please reference street names and cross streets or other location information if possible for clarification. In the comments section below, if known, list the other interfering entities and/or describe the interference.

Interference locations and interfering entities if know:

45. Does your agency use outdated radio equipment (Portables over 5-7 years old, mobiles over 10 years old)?

Yes ☒

No ☐

46. Please describe the age and general condition of your radios:

Describe radios: Most portables are 5 years old and most portables are 5 years old. The condition of the radios is fair.

47. Does your agency experience frequent portable or mobile radio failures?

Yes ☐

No ☒

48. Please describe the types of failures your agency experiences or make comments.

Types of radio failures or comments:

49. How long do portable and mobile radio repairs take to complete?

Comment: reasonable time frame

50. Who is responsible for your radio repair / service?

Comment: Clear Communications

51. Do major portions of your radio system or the entire radio system fail and how long does it take to recover from the failure?

Yes ☐

No ☒

For How Long:

52. Please provide any additional information regarding your Department's radio operations you believe would be of interest and/or value in relation to this study.

Comments:

53. In your opinion the next radio communications system should be (please explain in as much detail as possible and give reasons why):

Comments: A system that can have as much coverage as possible inside the borders of the county with additional coverage in areas that we may respond to outside of the county. The system should yield a more reliable portable with communications capabilities that would allow members to speak from inside a structure and in areas where terrain is an issue. These capabilities are essential to firefighter safety as a great deal of our operations are performed inside of building and on mountainous terrain.

Printed Name:	Brian Gordon	Title:	President
Department / Agency:	MCVFD	Contact Phone Number:	540-718-3987
Division:		Email Address:	bgordon@madisonco.virginia.gov

Please return the completed questionnaire with attachments to:

Robert Finks  
 Emergency Coordinator / 911 Director  
 Madison County, VA  
 Office: (540) 948-5144  
 Cell: (540) 718-0474  
 Email: [rfinks@madisonco.virginia.gov](mailto:rfinks@madisonco.virginia.gov)

If you have any questions regarding this questionnaire, please contact:

David Gelyana  
 Black & Veatch  
 Office: (312) 683-7811  
 Email: [gelyanad@bv.com](mailto:gelyanad@bv.com)  
 Or  
 Don Bowman  
 Black & Veatch  
 Office: (919) 463-3034  
 Email: [BowmanD2@bv.com](mailto:BowmanD2@bv.com)

## Radio System (Users) Questionnaire for Madison County, VA

The information you are providing is very important. The data we are collecting will be used to develop plans for an improved radio system.

### INSTRUCTIONS

Please insert your answers in the shadowed columns in the tables below. If there is a box (☐) , you may click on the appropriate box to enter an X. If the question is not applicable to your organization, you may leave the columns or boxes blank.

### ORGANIZATION INFORMATION

1. Provide the name of the Department / Company / Agency utilizing the radio system you are providing information about.

Department / Company / Agency:	MADISON COUNTY RESCUE SQUAD
Number of Career Personnel:	
Number of Volunteer Personnel:	35
Your Name and Title:	Jeff Jenkins , Communications Officer

2. Provide a brief statement of your Department / Company / Agency's purpose or mission.

Purpose or Mission: Emergency Medical Service ,County of Madison
--

3. Provide a brief statement of your Department / Company / Agency's organizational makeup.

Organizational Makeup: Made up of 40 Volunteer, EMT's And Medics
--

4. Provide a brief statement of your Department / Company / Agency's duties.

Duties: Provides Emergency Medical and Transport to the county of Madison
---

5. Provide a brief statement of your Department / Company / Agency's service area.

Service Area: 322 sq. Miles in the county and mutual aid to surrounding county's Greene, Culpeper, Rappahannock Orange
--

6. Describe the radio systems your agency use including radio communications and paging.

Description: Moto turbo System under the county
---

## SYSTEM LOADING

7. List the Vehicles / Apparatus and quantity used by your Department / Company / Agency.

Law Enforcement Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Patrol Vehicles:	
Number of Investigator Vehicles:	
Number of Special Unit Vehicles:	
Number of Command Vehicles:	
Fire Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of Engines:	
Number of Trucks:	
Number of Brush Trucks:	
Number of Special Unit Vehicles:	
Number of Command Vehicles:	
EMS Total Radio Equipped Vehicles:	7
Number of Staff Vehicles:	
Number of Transport Vehicles:	5
Number of Rapid Response Vehicles:	1
Number of Command Vehicles:	1
Schools Total Radio Equipped Vehicles:	
Number of Staff Vehicles:	
Number of School Buses:	
Municipal Agency Radio Equipped Vehicles:	
Staff Vehicles:	
Trucks:	
TOTAL NUMBER OF VEHICLES WITH RADIOS:	

8. List the locations and quantity of control station radios (base stations) used by your Department / Company / Agency.

Locations	Number of Control Stations (Base Stations)
Madison Station	1



9. Please provide the number / frequency band / manufacturer / model numbers of the radios your Department / Company / Agency uses. (Please include spares)

	Quantity	Frequency Band (UHF / VHF / 700-800 MHz)	Manufacturer	Model
Example	10	UHF/VHF	Kenwood	NX-300G
Mobiles	7	MOTOTRBO	Motorola	XPR4580
Mobiles	1	MOTOTRBO	Motorola	
Mobiles				
Mobiles				
Mobiles				
Portable s	60	VHF MOTOTRBO	Motorola	XPR6550
Portable s				
Portable s				
Portable s				
Portable s				
Voice Pagers	60	VHF	Motorola	Min.5



Voice Pagers				
Control Stations				
Control Stations				
Control Stations				
Control Stations				
Control Stations				

10. Please provide the estimated percentage of growth in the number of radios estimated over the next 10 years (example: 2%, 3%, 4%, 5%, etc.).

Radio Type	2018	2020	2022	2024	2026	2028
Mobiles						
Portables						
Voice Pagers						
Control Stations						

## RADIO UTILIZATION

11. Are portable radios assigned to individuals or rotated to various personnel?

Individuals <input checked="" type="checkbox"/>	Rotated <input type="checkbox"/>
---	----------------------------------

12. Are the portable radios taken home after duty hours?

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
---	-----------------------------

Comments: Sr. Members Carry their own

13. Are portable radios equipped with external speaker microphones?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

14. Check the box for the type of antenna used.

3" Stubby <input type="checkbox"/>	6" Standard <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
------------------------------------	---	--------------------------------

Comments:

15. What type of batteries are used on your portable radios?

NiCad <input checked="" type="checkbox"/>	Nickel Metal Hydride <input type="checkbox"/>	Lithium Ion <input type="checkbox"/>
---	---	--------------------------------------

16. What is the average age of your portable radio batteries?

One Year <input type="checkbox"/>	Two Years <input checked="" type="checkbox"/>	More than 2 years <input type="checkbox"/>
-----------------------------------	---	--

17. When were your portable batteries last replaced?

1 Year Ago <input type="checkbox"/>	2 Years Ago <input checked="" type="checkbox"/>	3 Years Ago <input type="checkbox"/>	More Than 3 Years Ago <input type="checkbox"/>
-------------------------------------	---	--------------------------------------	--

18. How long is a typical shift or how many hours do you require your portable batteries to last before needing to be recharged?

8 hours <input type="checkbox"/>	12 hours <input checked="" type="checkbox"/>	14 hours <input type="checkbox"/>	24 hours <input type="checkbox"/>	Other:
----------------------------------	--	-----------------------------------	-----------------------------------	--------

19. Does your agency have a portable battery conditioner analyzer?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

20. What type of portable battery chargers does your agency use?

Individual Battery Charger <input checked="" type="checkbox"/>	Bank Type Gang Charger <input type="checkbox"/>
--	---

21. Does your agency have mobile radios installed in personally owned vehicles?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

## DAILY OPERATIONS

22. What time of day are your radios used and how many radios are in use per shift?

Shift	Number of Radios in Use by Shift
<input type="checkbox"/> Day	
<input type="checkbox"/> Evening	
<input type="checkbox"/> Night	
<input type="checkbox"/> Any or All	
X Varies	Anytime

23. How many calls did your agency respond to last year?

Number of calls:2000
----------------------

24. Are members of your organization issued cell phones?

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
------------------------------	--

25. What cellular carrier is used for issued cell phones and how many are issued?

Cell Carrier:	Number of cells phones issued:
---------------	--------------------------------

26. Are cell phones used to provide communications in areas where radio coverage is weak or non-existent?

Yes ☐No ☒

27. What areas or your locality are cell phones used where the radio system does not provide communications?

Answer: transport to the hospital talking to charge nurses

## INTEROPERABILITY INFORMATION

28. What other agencies / departments *in your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer:

Sheriff, and fire could also contact school if available

29. What other agencies / departments *outside of your locality* do you typically contact regularly by radio and how do you use the radio to communicate with them (common channel, different radio, or console patch)?

Answer: Multiple Medflight services

30. Does your agency have adequate radio communications capabilities with other agencies?

Yes ☐No ☒

31. What agencies do you experience radio communication problems with?

Agencies and describe the problems: Culpeper ,

32. What other agencies / departments would you like to be able to have direct radio contact with in the future?

Answer: Culpeper co

## COVERAGE REQUIREMENTS

33. Please generally describe the geographic areas where *mobile radio coverage* is typically required for daily operations.

Answer: Multiple county's and all around our local area

34. Please generally describe the geographic areas where *portable radio coverage* is typically required for daily operations.

Answer: mostly in the Madison county jurisdiction

35. Is there poor or unreliable radio coverage in areas of your agency's responsibility?

Yes ☒

No ☐

36. If there are areas of poor radio coverage, describe the approximate locations. Please provide street names, hundred blocks, cross streets, or landmarks. Please include any building names and street addresses your have experienced poor radio coverage. Also describe the coverage as poor, occasional, or no coverage. Please state if the poor coverage is transmit or receive.

Answer Nethers Mill area of the county

## FUTURE SYSTEM GOALS

37. Please provide the requirements for radio and radio system features desired or required by your agency.

Features	Desired	Required
Emergency Alert with ID Display	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Unit ID on Transmissions	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Individual Call Capability	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Telephone Interconnect	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Voice Encryption	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
GPS Operation	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Multi-Band Operation	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Text Messaging	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Integrated Voice and Data	Desired <input checked="" type="checkbox"/>	Required <input type="checkbox"/>
Advanced Software	Desired <input type="checkbox"/>	Required <input type="checkbox"/>
Other (Identify/Explain below)	Desired <input type="checkbox"/>	Required <input type="checkbox"/>

38. Please list other radio or radio system features your agency would desire or require in a new radio system. If you listed any features above as required, please give an explanation, reason or an example of a use for the feature.

Answer: would like text paging to individuals cell phone with address and type of call

## CURRENT RADIO SYSTEM CONCERNS OR PROBLEMS

Please identify any problems you are currently experiencing with your existing radio system:

39. Does your radio system have too many radios sharing a channel or channels?

Yes ☐

No ☒

40. What is the more common causes or times when there is channel congestion?

Answer: major wrecks and fires

41. How often does channel congestion occur?

Frequently ☐

Occasionally ☒

Never ☐

42. If channel congestion occurs, how long does it take to get a clear channel to communicate? Please provide your comments and provide examples.

Answer:

43. Does your radio system experience interference from other entities?

Frequently ☐

Occasionally ☐

Never ☒

44. Please reference street names and cross streets or other location information if possible for clarification. In the comments section below, if known, list the other interfering entities and/or describe the interference.

Interference locations and interfering entities if know:

45. Does your agency use outdated radio equipment (Portables over 5-7 years old, mobiles over 10 years old)?

Yes ☒

No ☐

46. Please describe the age and general condition of your radios:

Describe radios: over 5 years but in good condition

47. Does your agency experience frequent portable or mobile radio failures?

Yes ☐

No ☒

48. Please describe the types of failures your agency experiences or make comments.

Types of radio failures or comments:

49. How long do portable and mobile radio repairs take to complete?

Comment:

50. Who is responsible for your radio repair / service?

Comment Clear Communications

51. Do major portions of your radio system or the entire radio system fail and how long does it take to recover from the failure?

Yes ☒

No ☐

For How Long: Not long

52. Please provide any additional information regarding your Department's radio operations you believe would be of interest and/or value in relation to this study.

Comments:

53. In your opinion the next radio communications system should be (please explain in as much detail as possible and give reasons why):

Comments:

User friendly, more veritable to other county's

Printed Name:

Jeff Jenkins

Title:

Communications  
Officer

Department /  
Agency:

Madison County  
Rescue Squad

Contact Phone  
Number:

540-718-7640

Division:

Email Address:

[hvyrsq08@gmail.com](mailto:hvyrsq08@gmail.com)



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Please return the completed questionnaire with attachments to:

Robert Finks  
Emergency Coordinator / 911 Director  
Madison County, VA  
Office: (540) 948-5144  
Cell: (540) 718-0474  
Email: [rfinks@madisonco.virginia.gov](mailto:rfinks@madisonco.virginia.gov)

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If you have any questions regarding this questionnaire, please contact:

David Gelyana  
Black & Veatch  
Office: (312) 683-7811  
Email: [gelyanad@bv.com](mailto:gelyanad@bv.com)  
Or  
Don Bowman  
Black & Veatch  
Office: (919) 463-3034  
Email: [BowmanD2@bv.com](mailto:BowmanD2@bv.com)



## APPENDIX B: EXISTING VHF RADIO SYSTEM COVERAGE – DIGITAL CHANNEL

### Calculated Effective Faded Received Sensitivity Portable Radio –Received Signal Parameters

	DAQ3.4 Outbound	DAQ3.4 Inbound	
12 dB SINAD Reference Sensitivity (from equipment spec sheets)	-119.0	-120.0	dBm
Static C/N (from TIA TSB-88.1D ANNEX A Table A.1)	5.3	5.3	dB
Faded C/(I+N) (from TIA TSB-88.1D ANNEX A Table A.1)	15.6	15.6	dB
Effective Faded Received Sensitivity	<b>-108.7</b>	<b>-109.7</b>	dBm
Additional Noise Degradation	3.0	3.0	dB
Net Faded Received Sensitivity	<b>-105.7</b>	<b>-106.7</b>	dBm

## Appendix B1: 911 Center Existing Coverage

Figure 3: Mobile Coverage – Outbound – 911 Center

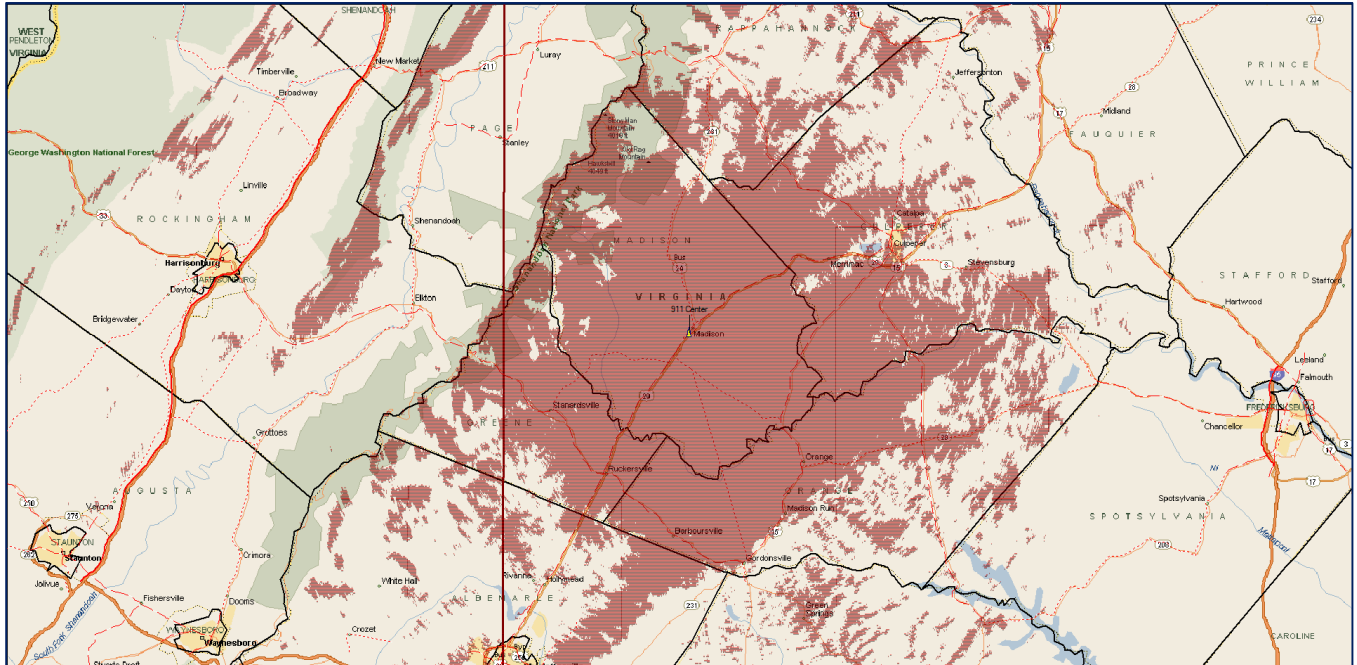


Figure 4: Mobile Coverage – Inbound – 911 Center

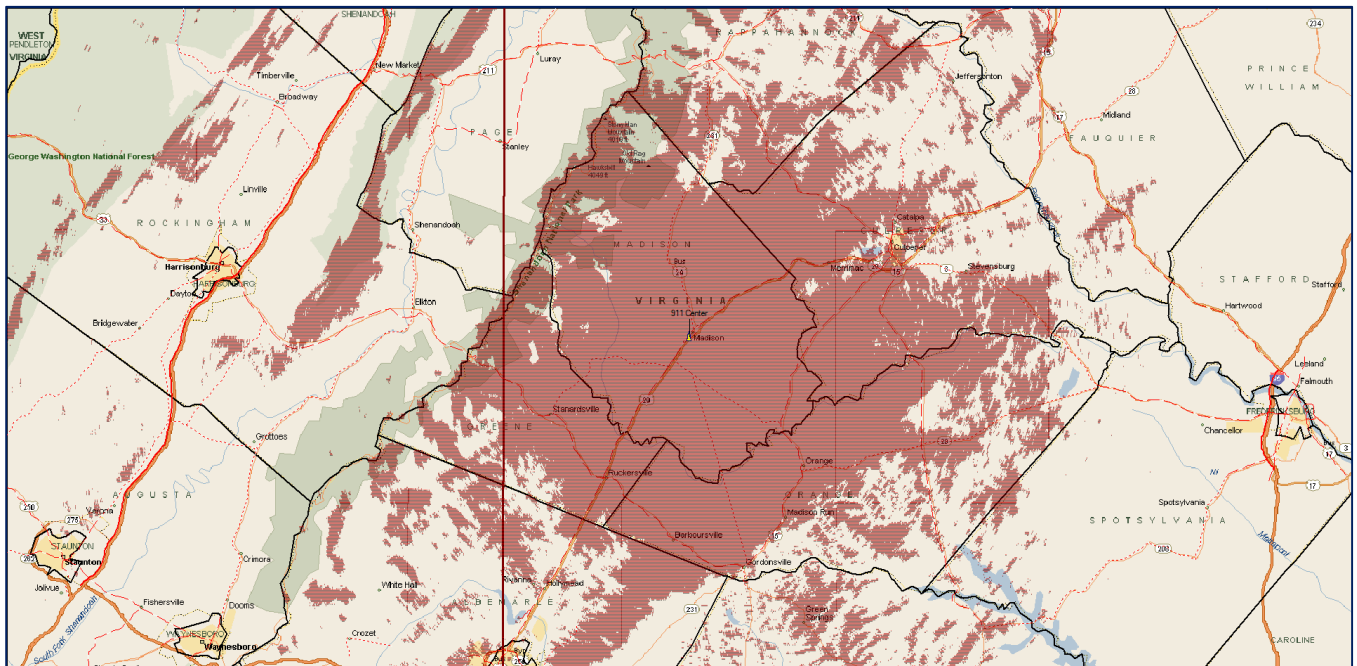


Figure 5: Portable On-Hip Outdoor Coverage - Outbound - 911 Center

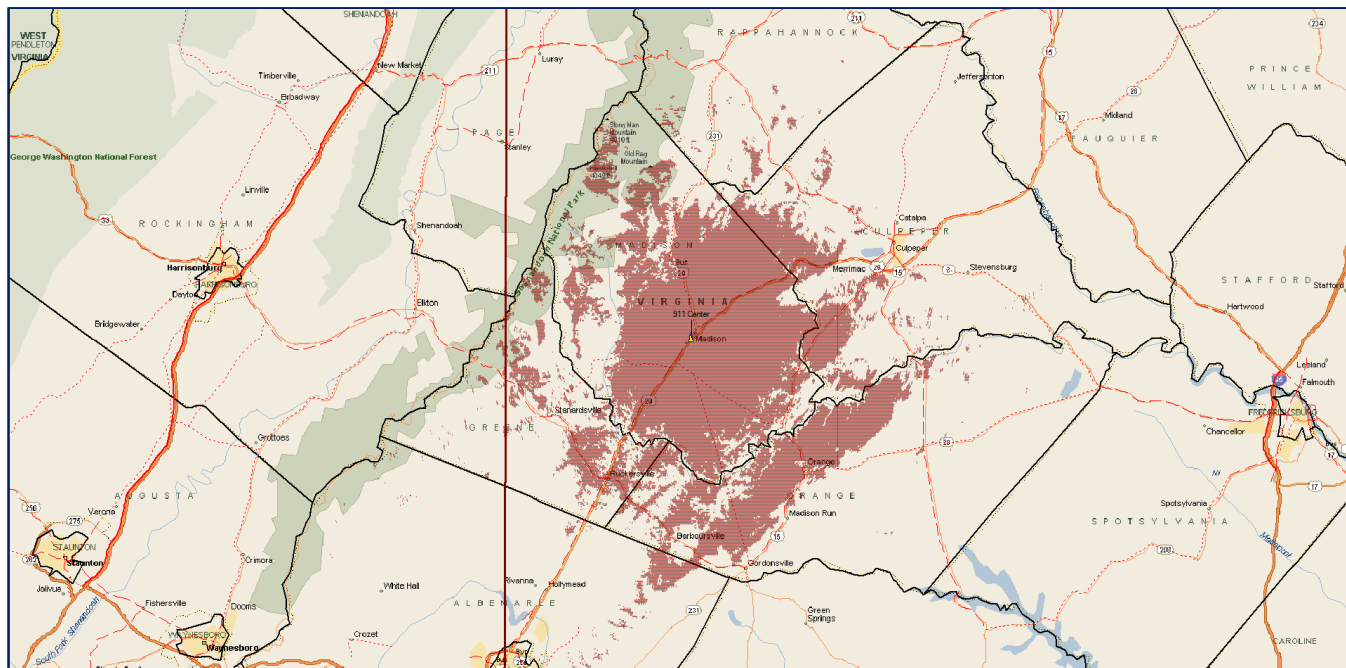


Figure 6: Portable On-Hip Outdoor Coverage - Inbound - 911 Center

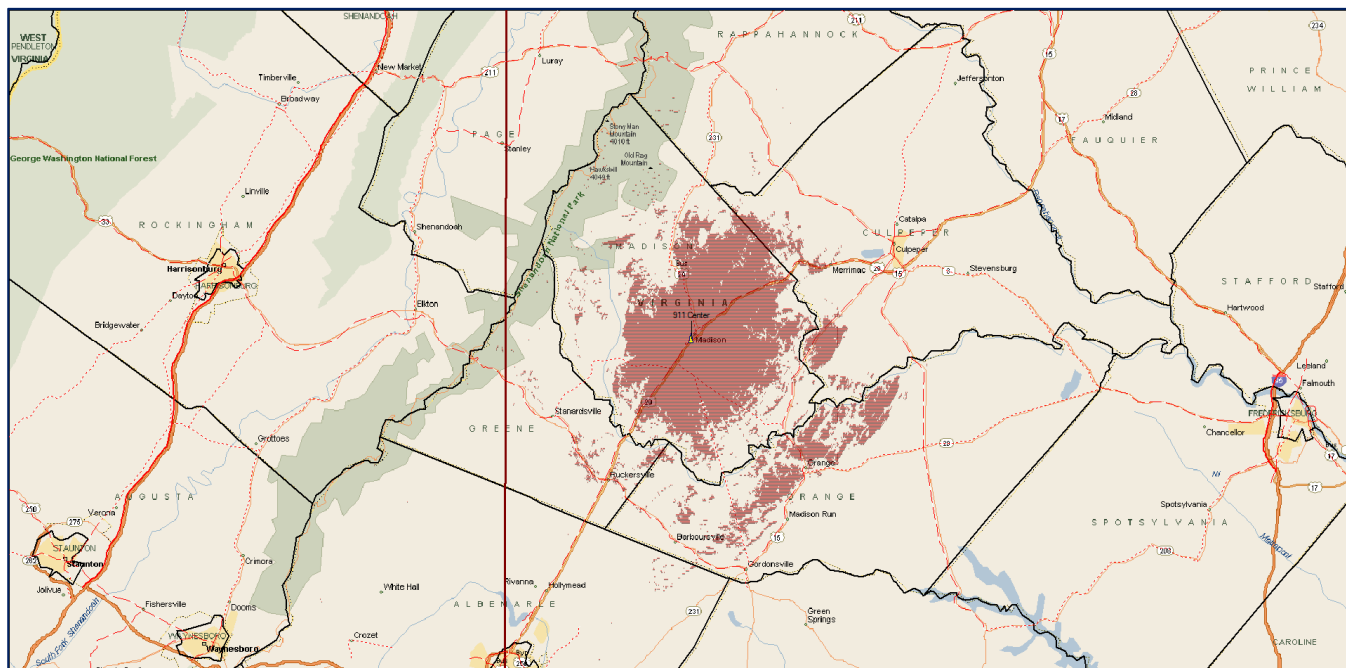


Figure 7: Portable On-Hip Indoor Coverage - 6 dB Building - Outbound - 911 Center

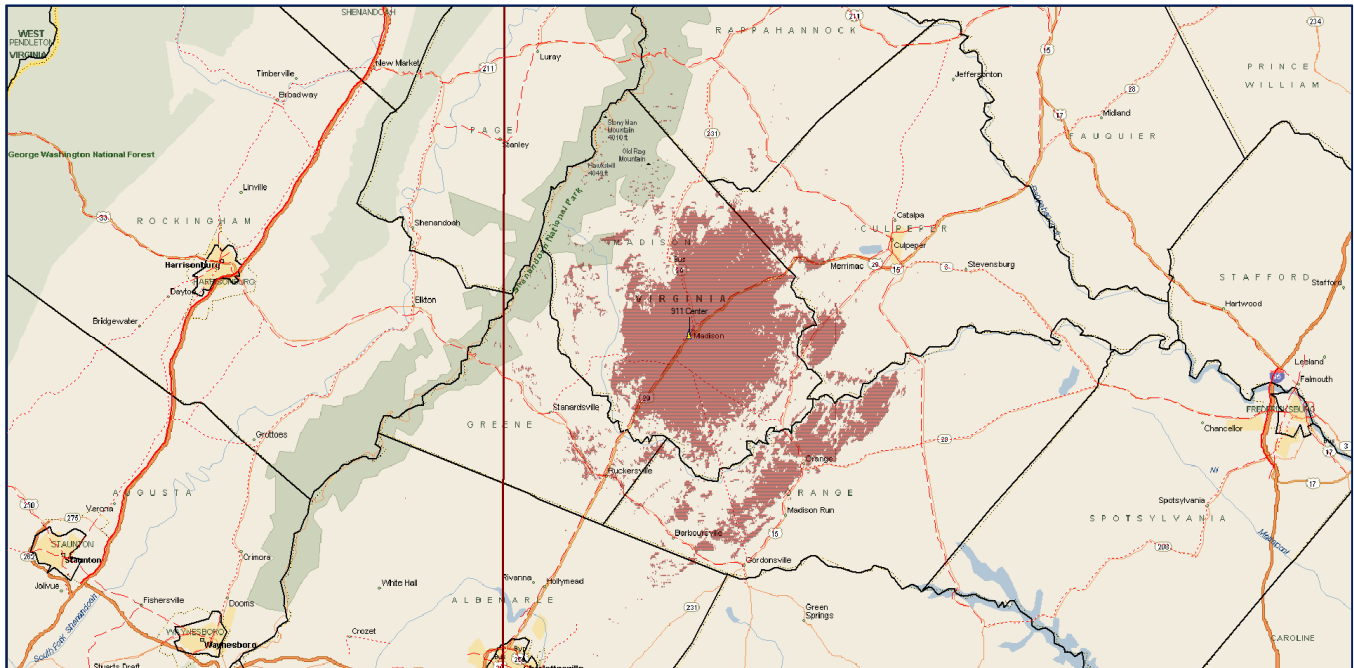


Figure 8: Portable On-Hip Indoor Coverage - 6 dB Building - Inbound - 911 Center

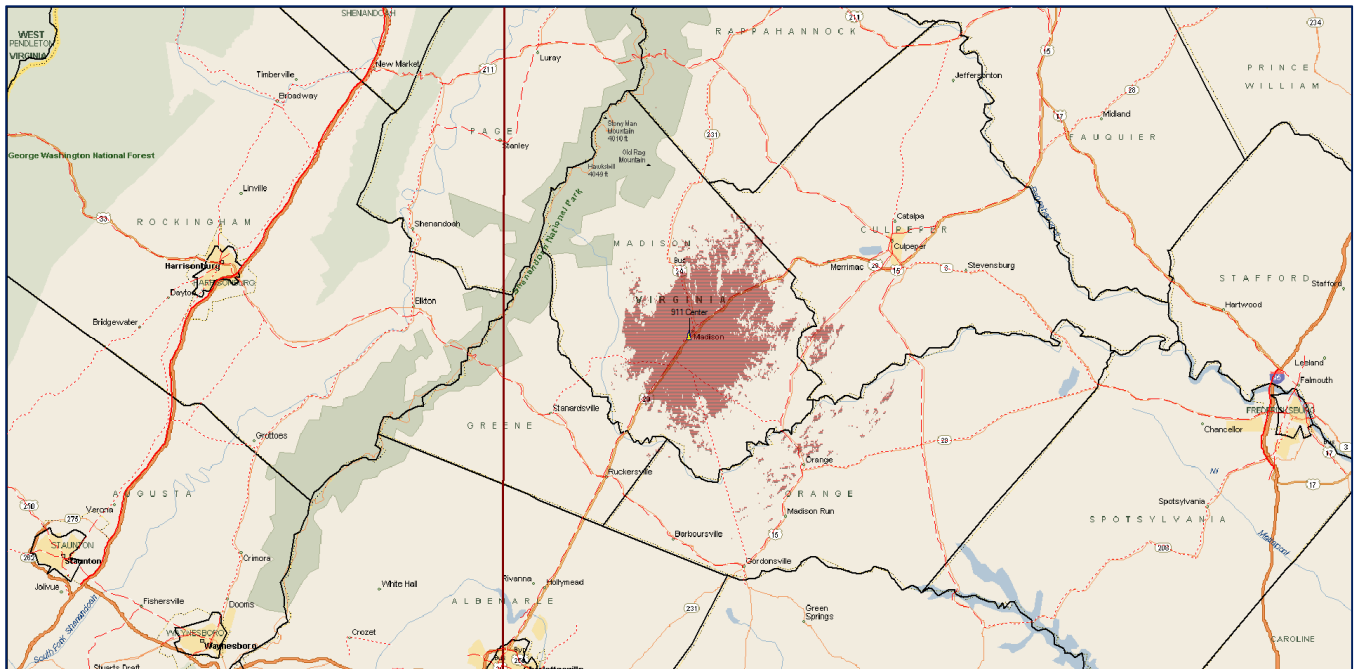




Figure 9: Portable On-Hip Indoor Coverage - 12 dB Building - Outdoor - 911 Center

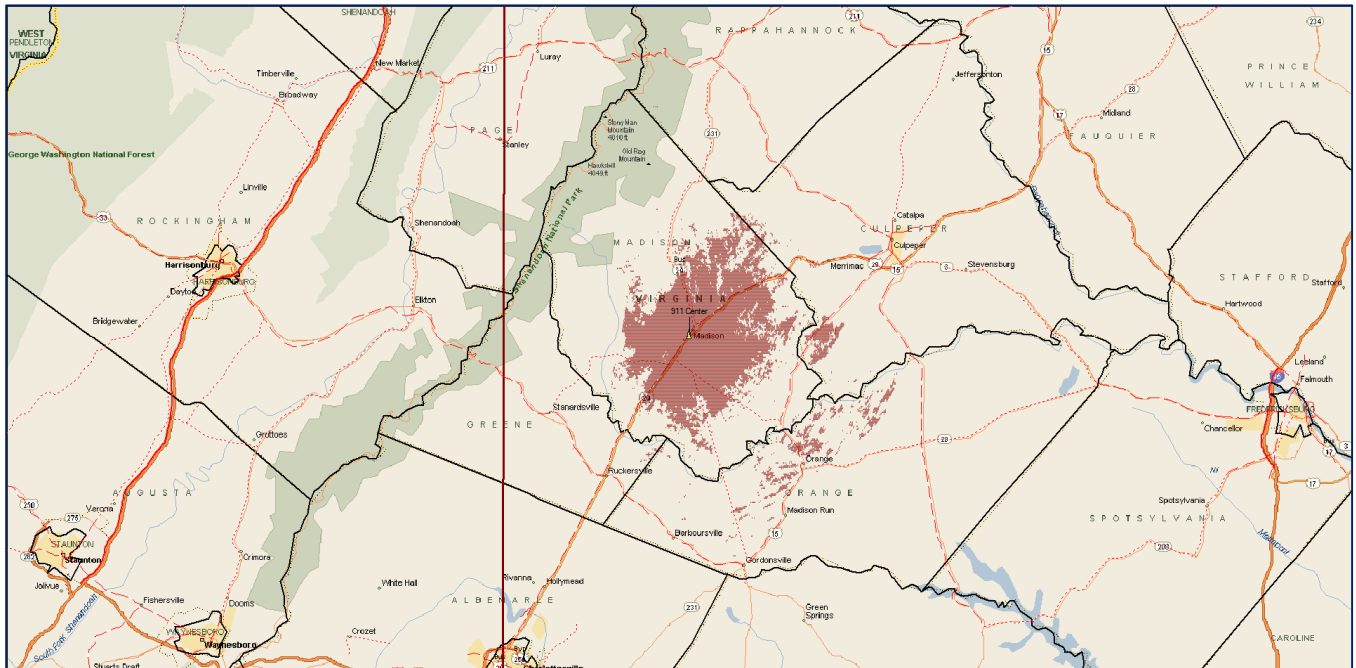


Figure 10: Portable On-Hip Indoor Coverage - 12 dB Building - Inbound - 911 Center

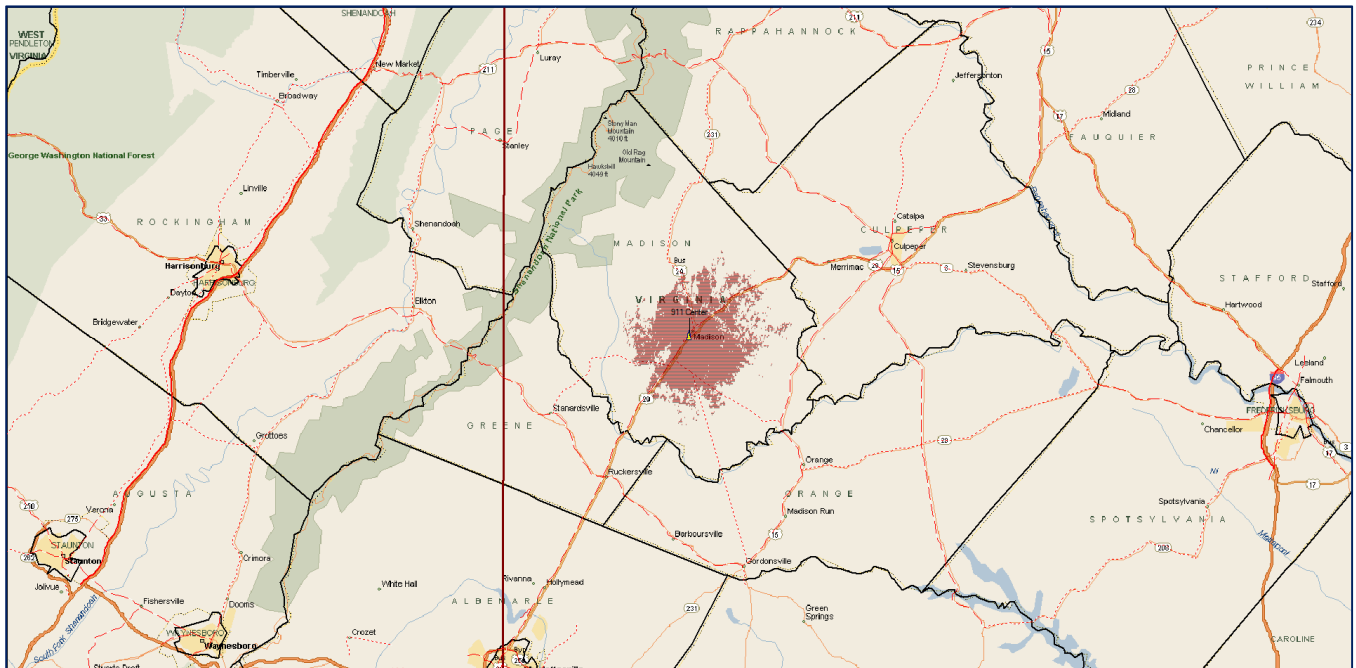


Figure 11: Portable On-Hip Indoor Coverage - 20 dB Building - Outbound - 911 Center

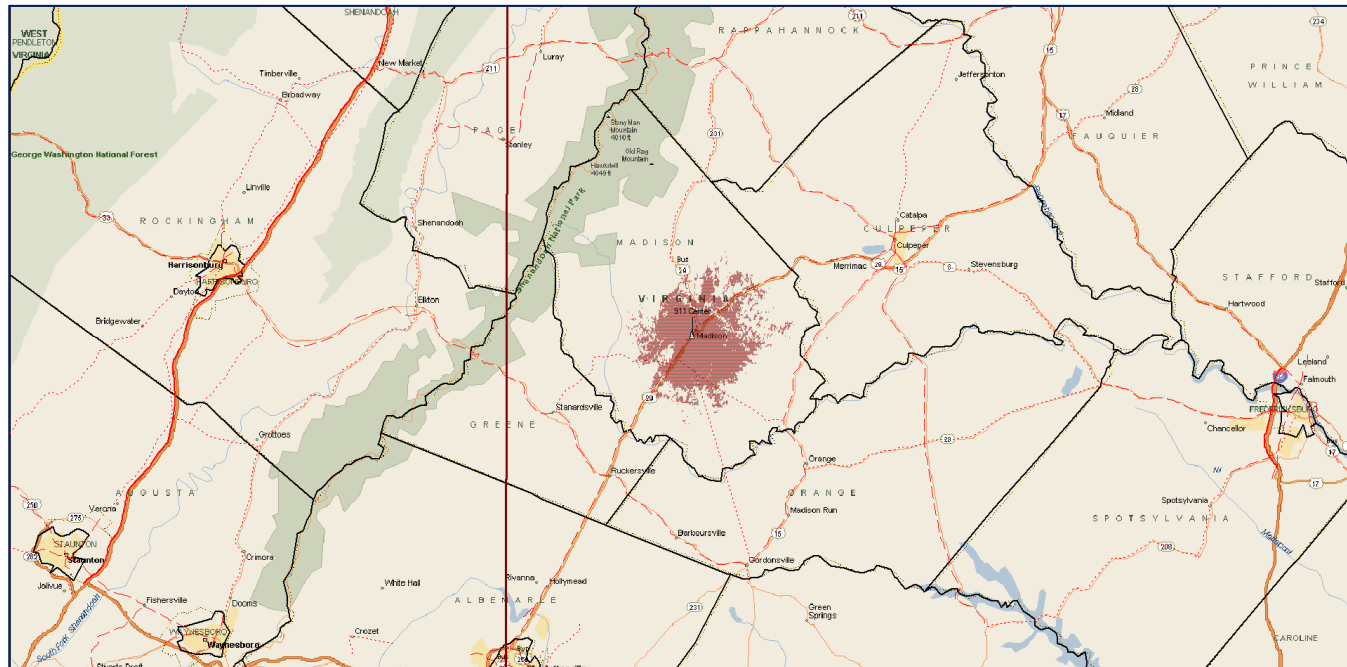
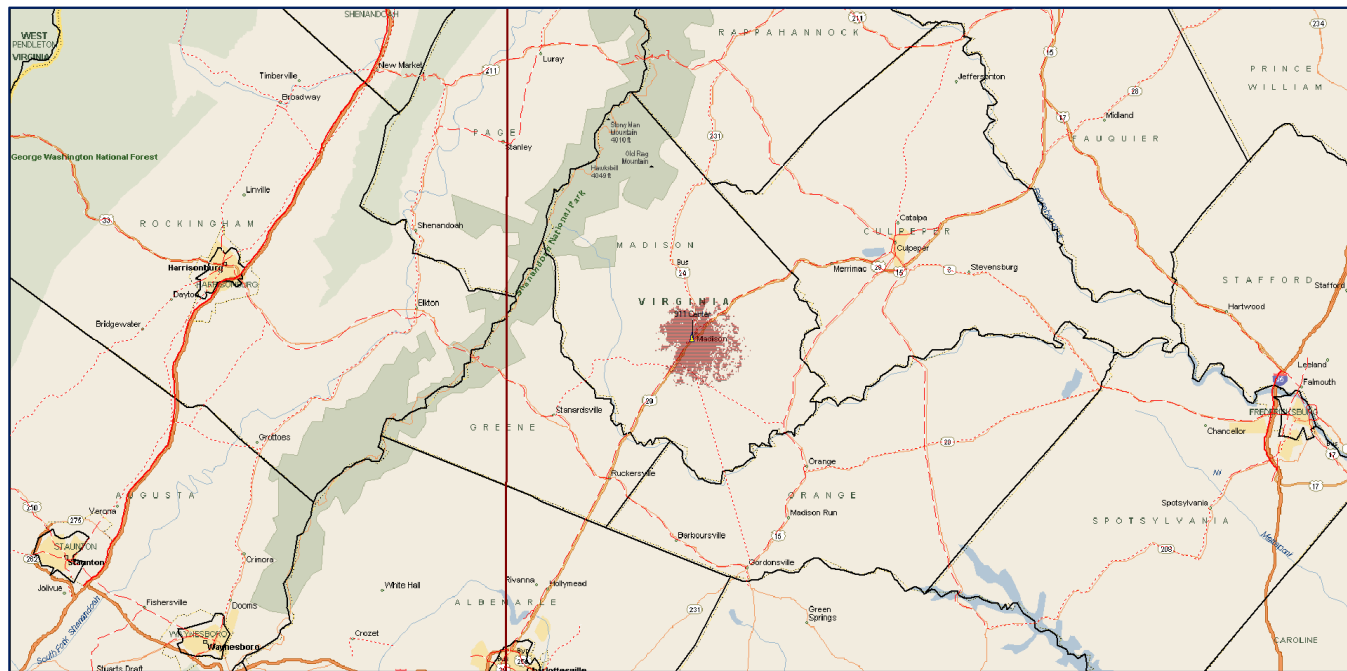


Figure 12: Portable On-Hip Indoor Coverage - 20 dB Building - Inbound - 911 Center





## Appendix B2: Blakey Ridge Existing Coverage

Figure 13: Mobile Coverage - Outbound - Blakey Ridge

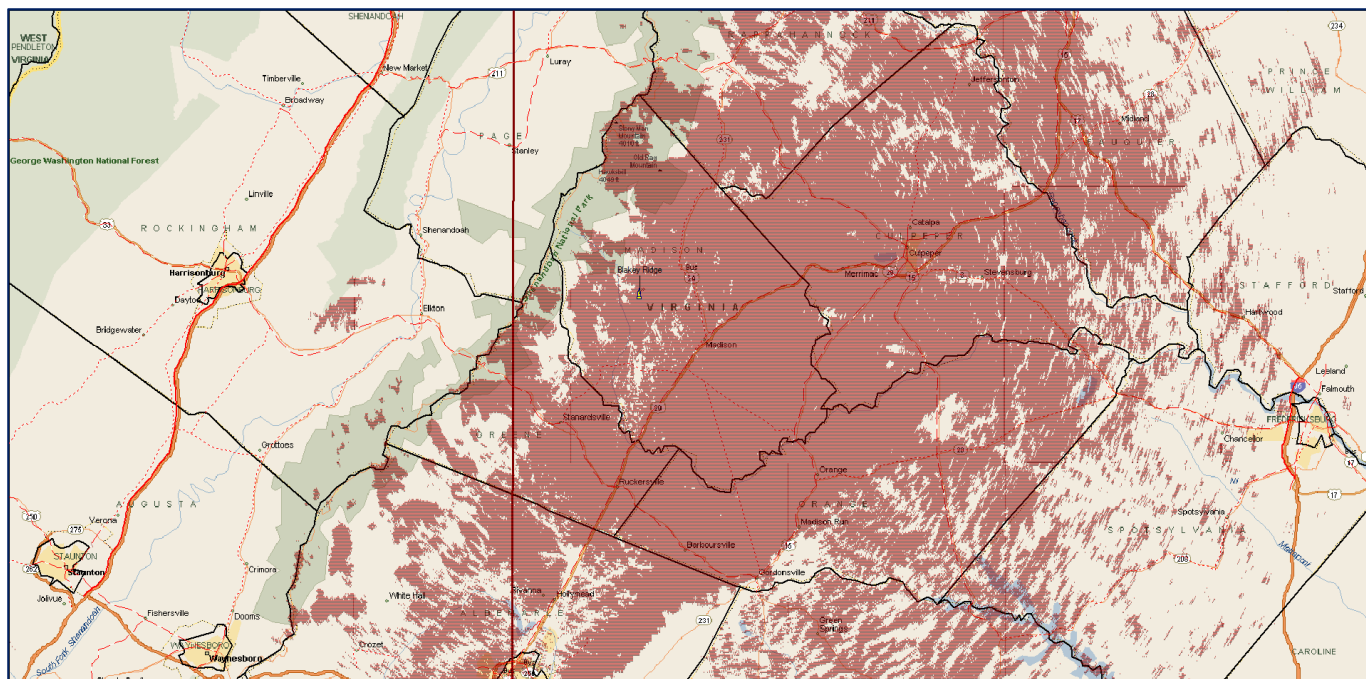


Figure 14: Mobile Coverage - Inbound - Blakey Ridge

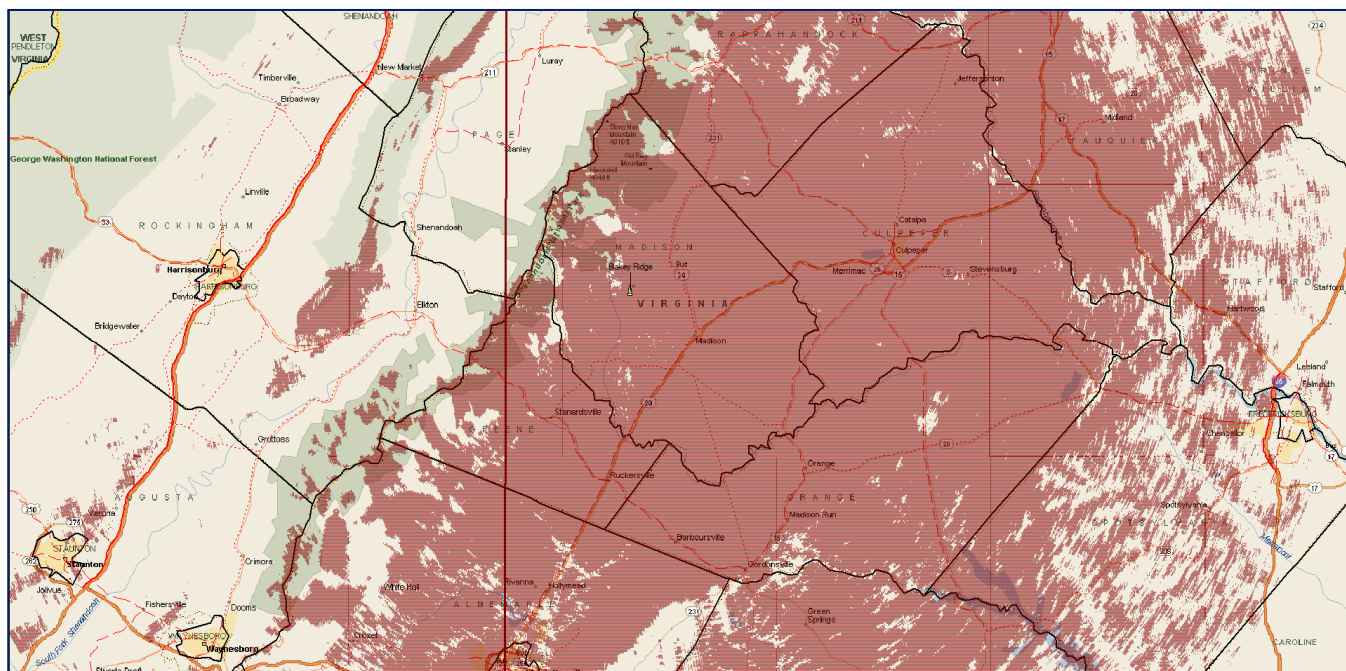


Figure 15: Portable On-Hip - Outbound - Blakey Ridge

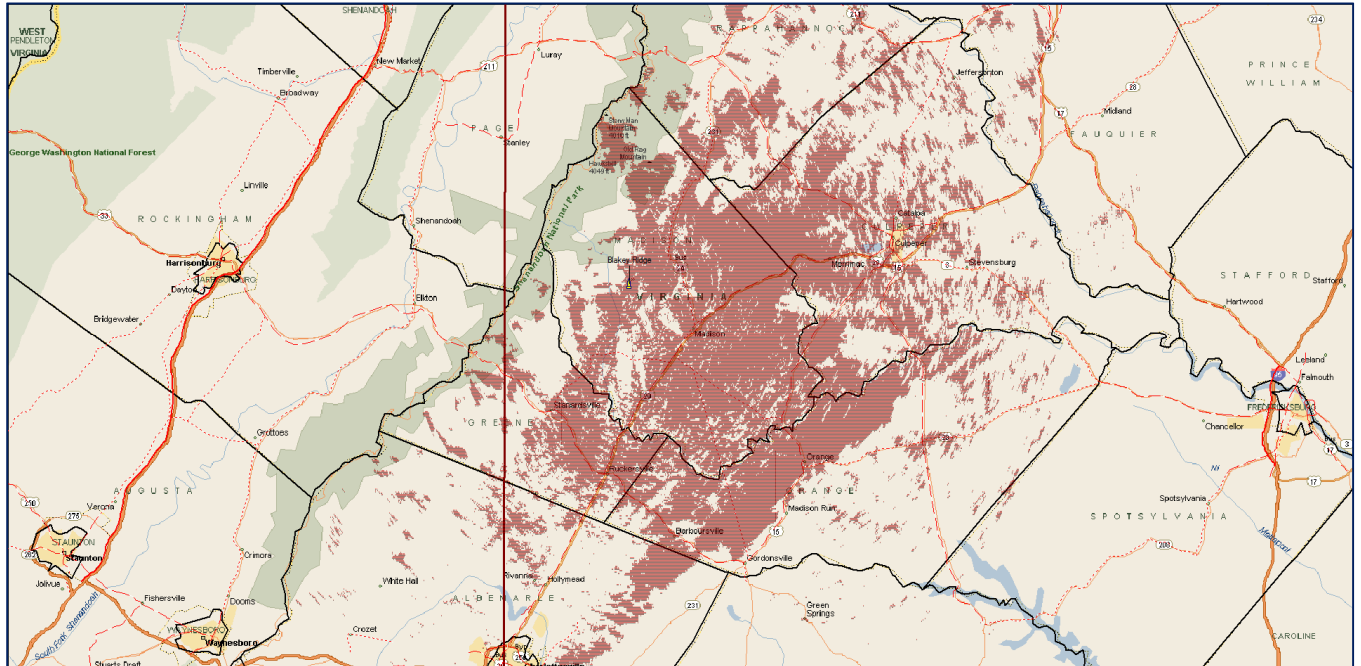


Figure 16: Portable On-Hip Outdoor Coverage – Inbound – Blakey Ridge

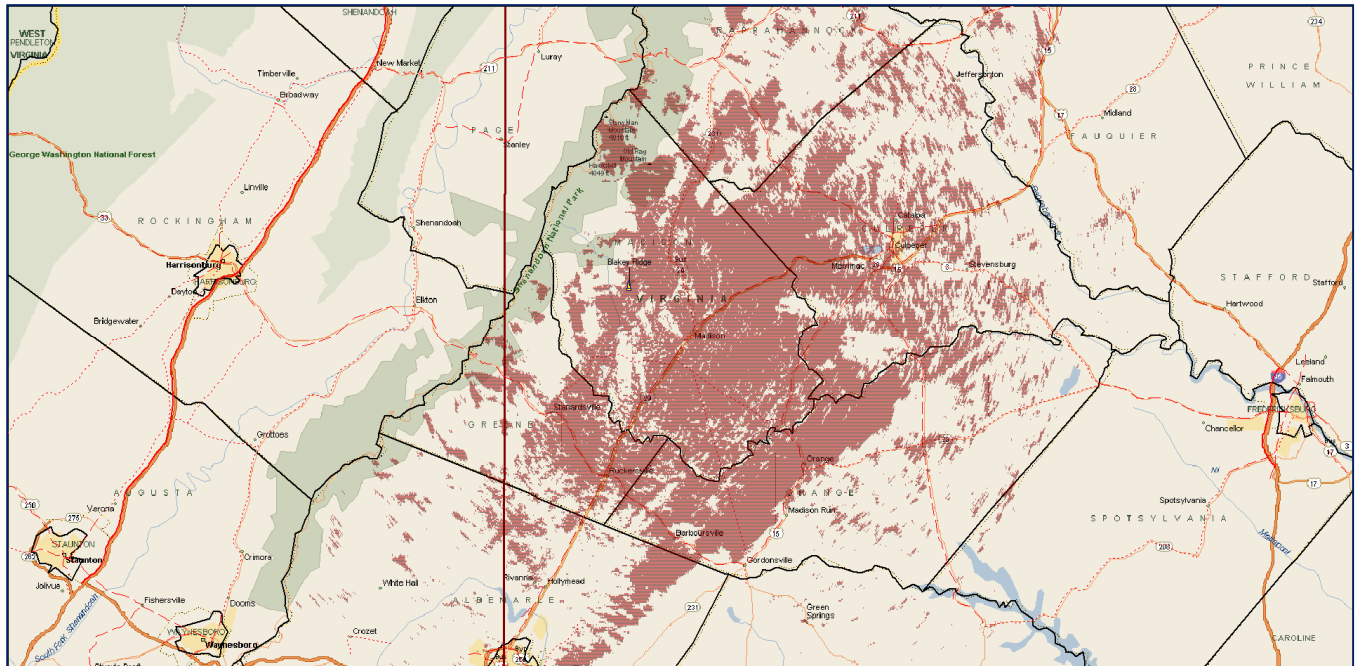


Figure 17: Portable On-Hip Indoor Coverage - 6 dB Building - Outdoor - Blakey Ridge

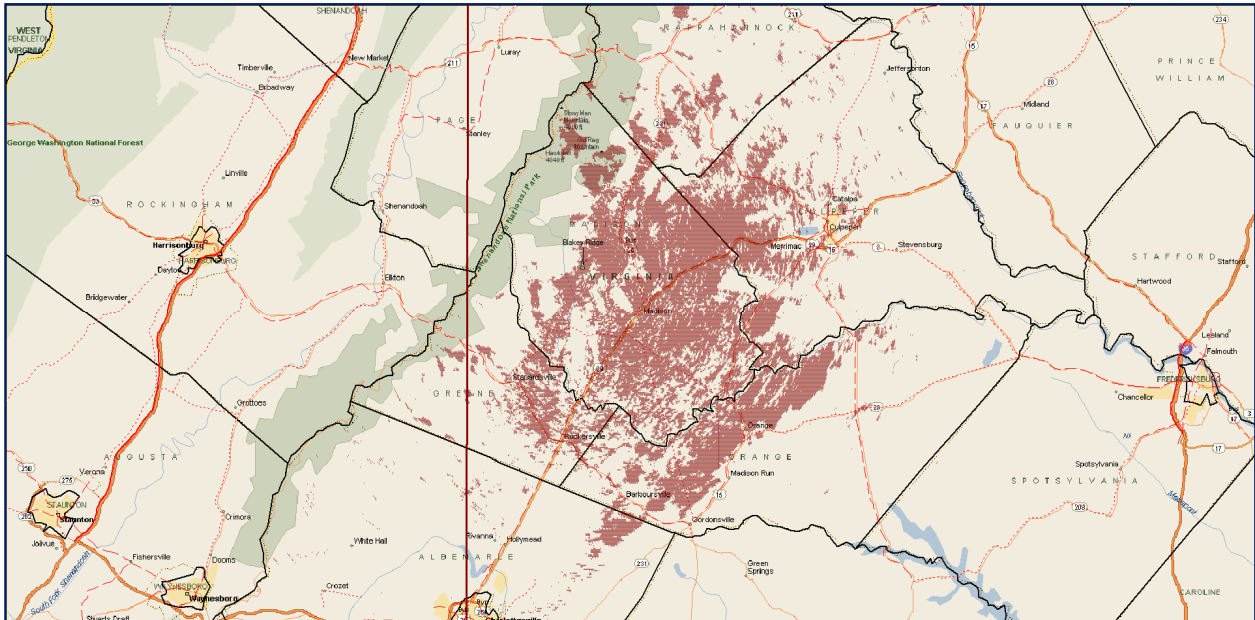


Figure 18: Portable On-Hip Indoor Coverage - 6 dB Building - Inbound - Blakey Ridge

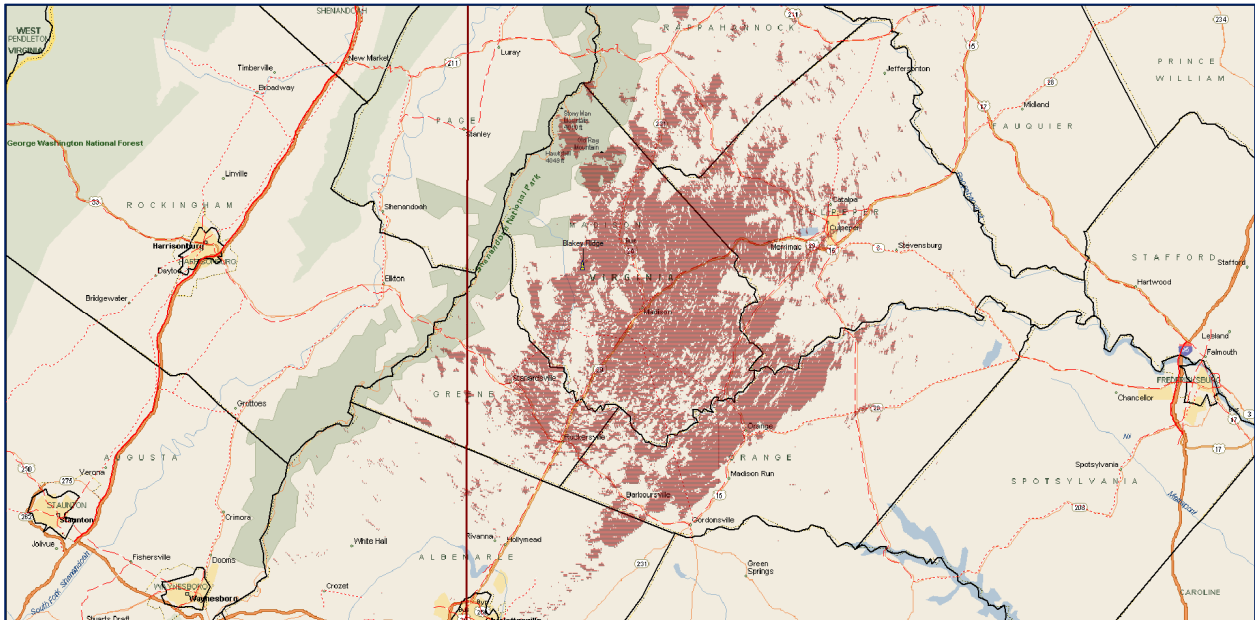




Figure 19: Portable On-Hip Indoor Coverage - 12 dB Building - Outbound - Blakey Ridge

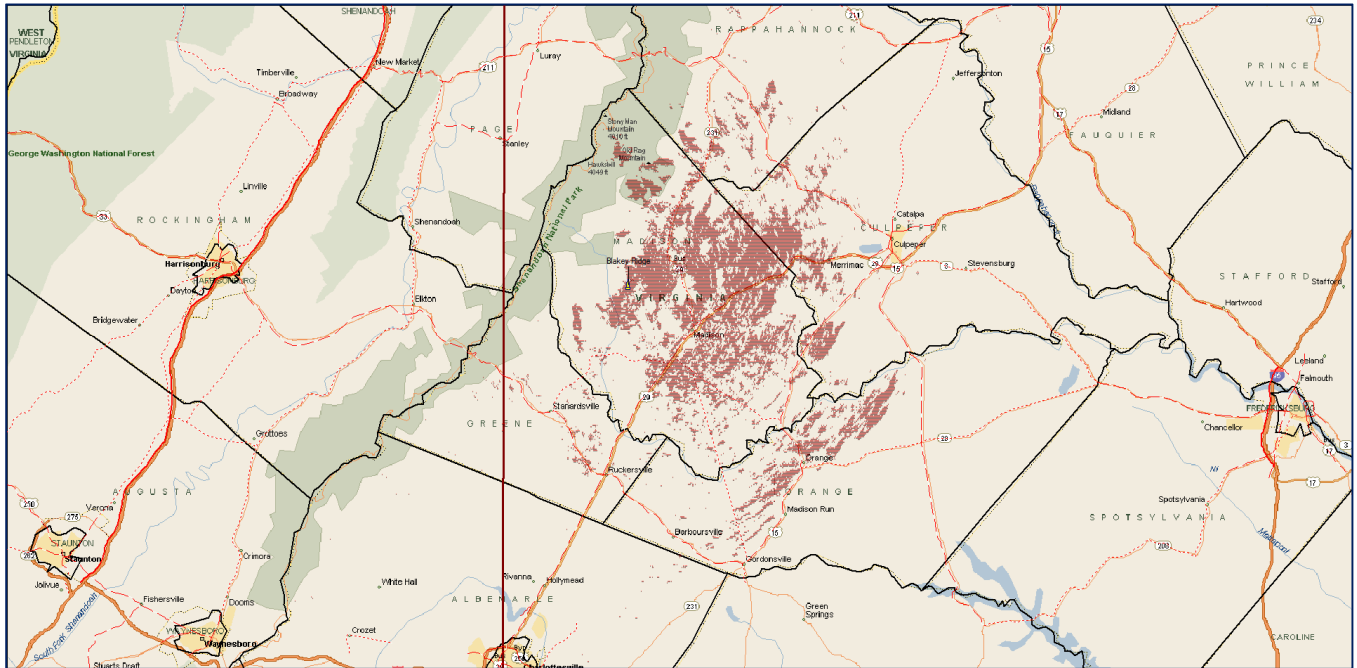


Figure 20: Portable On-Hip Indoor Coverage - 12 Building - Inbound - Blakey Ridge

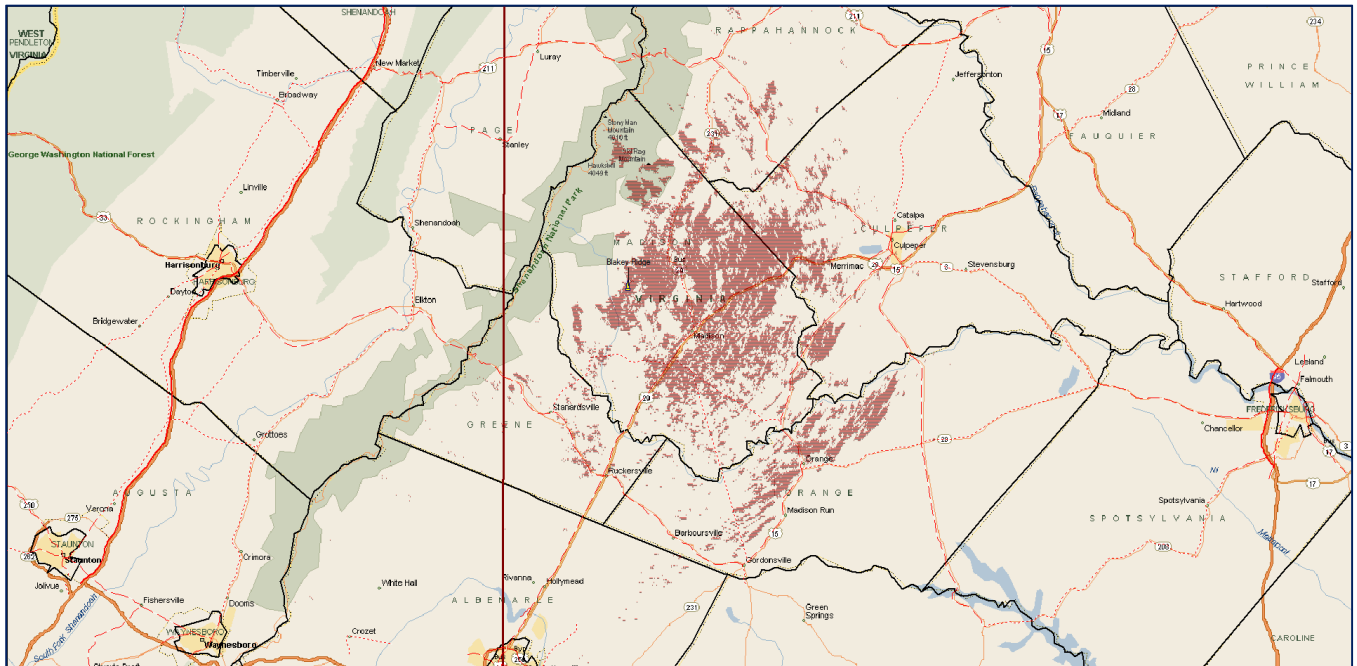


Figure 21: Portable On-Hip Indoor Coverage - 20 dB Building - Outbound - Blakey Ridge

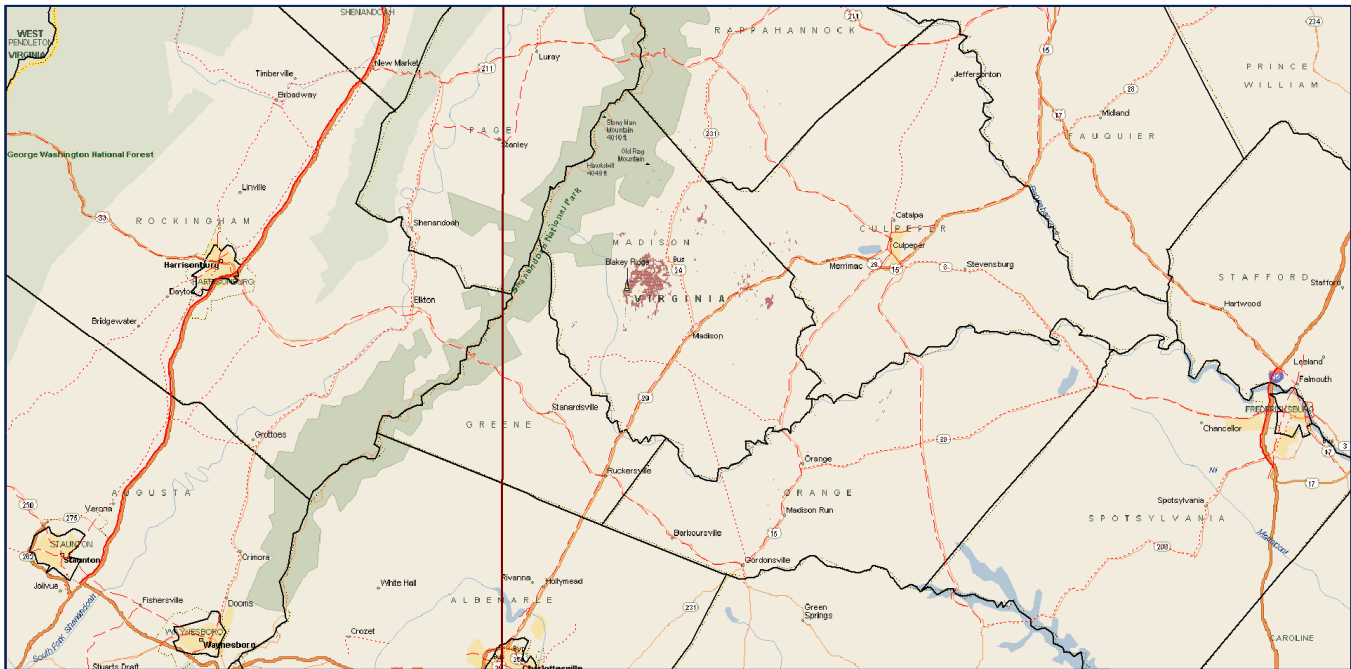
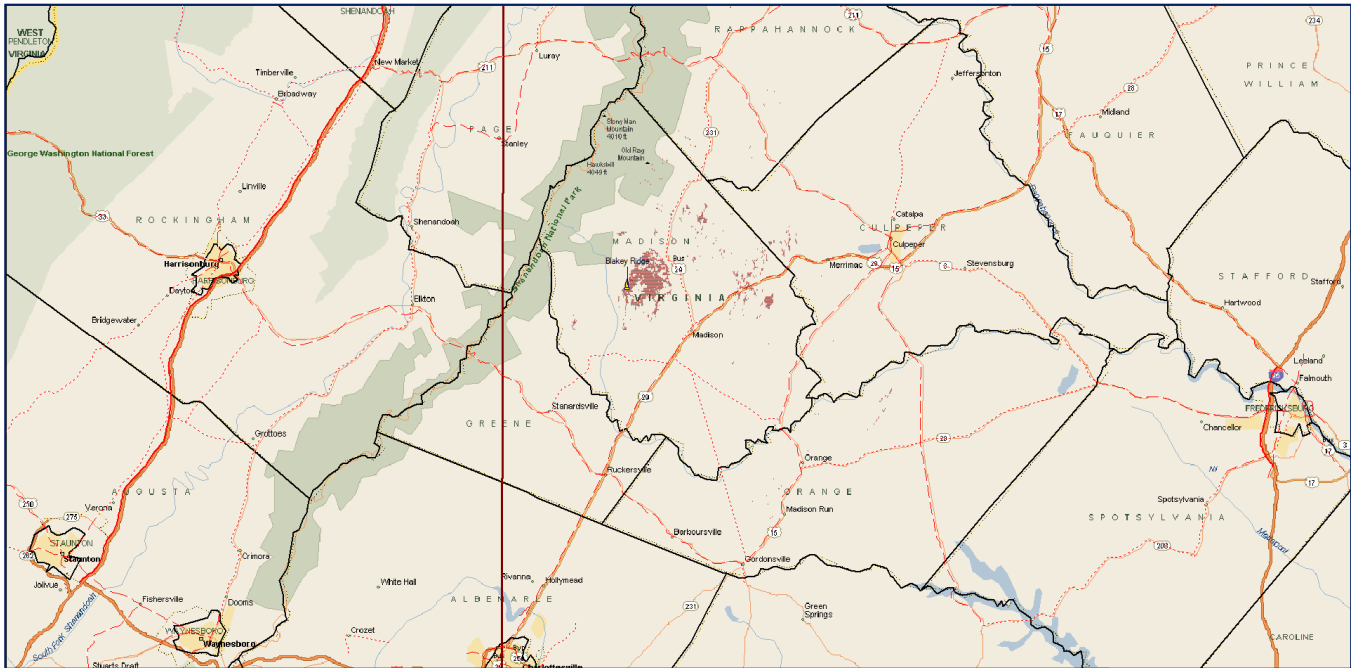


Figure 22: Portable On-Hip Indoor Coverage - 20 dB Building - Inbound - Blakey Ridge



## Appendix B3: Beautiful Run Existing Coverage

Figure 23: Mobile Coverage - Outbound - Beautiful Run

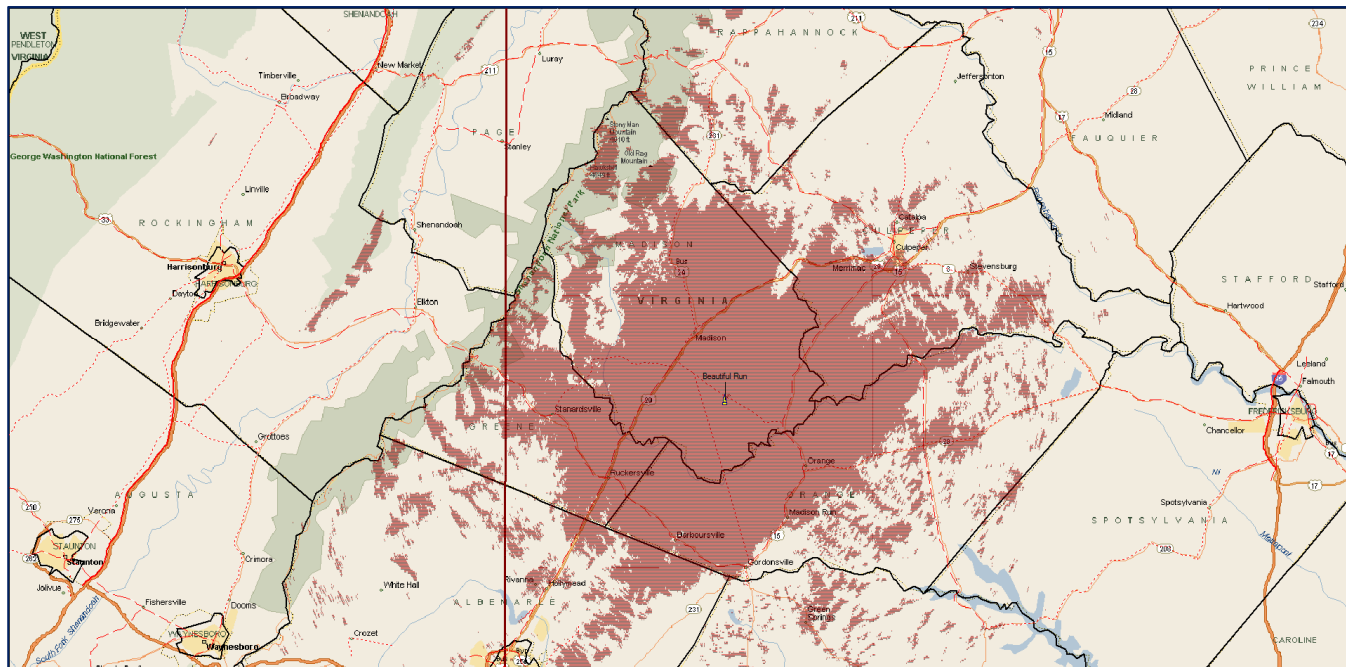


Figure 24: Mobile Coverage - Inbound - Beautiful Run

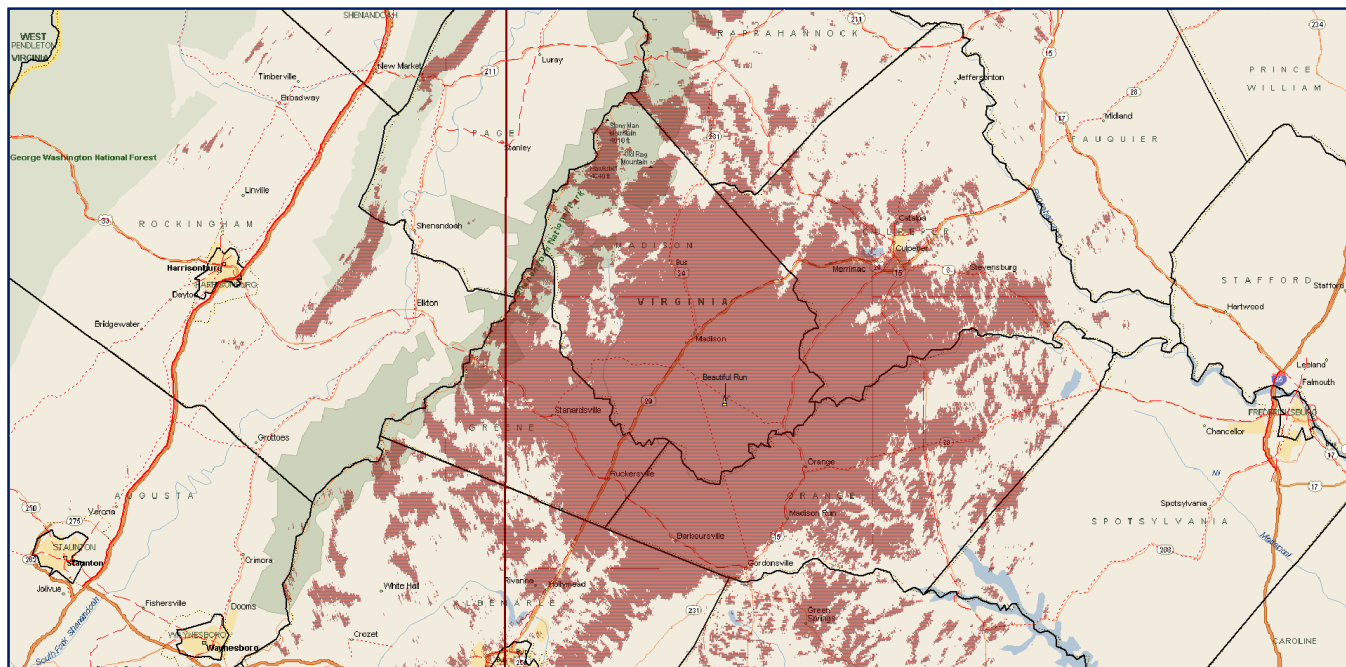




Figure 25: Portable On-Hip Outdoor Coverage - Outbound - Beautiful Run

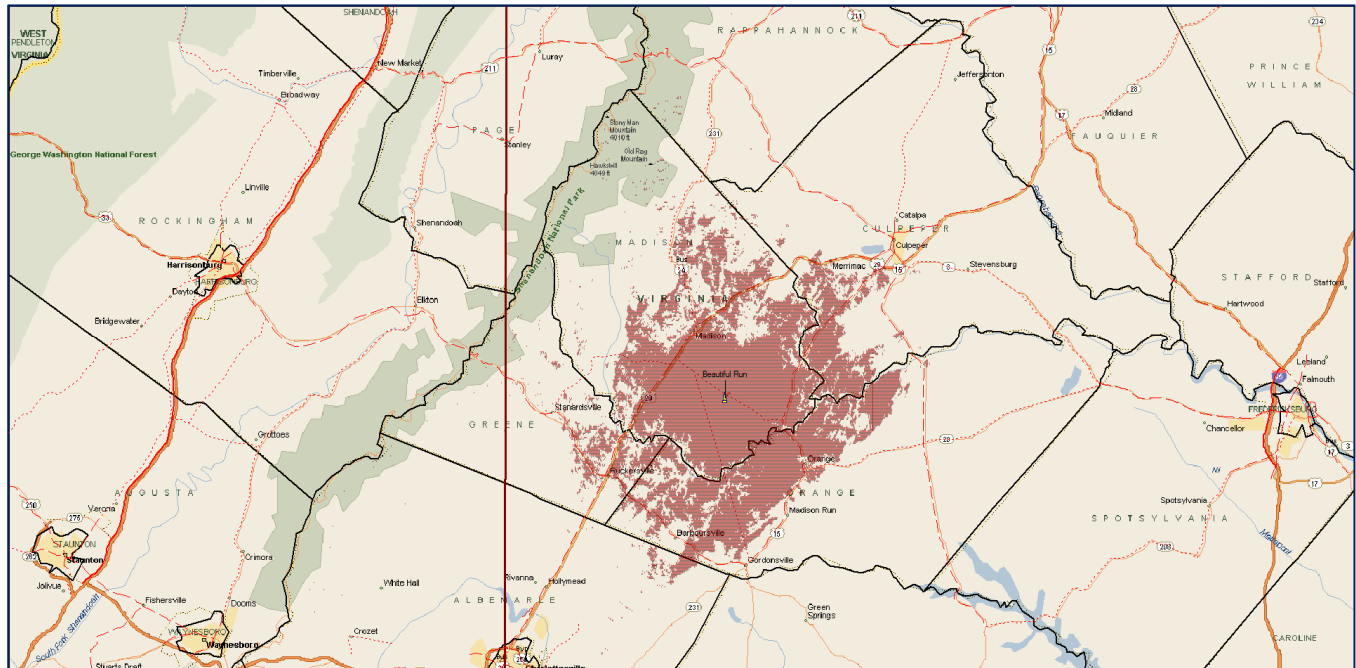


Figure 26: Portable On-Hip Outdoor Coverage - Inbound - Beautiful Run

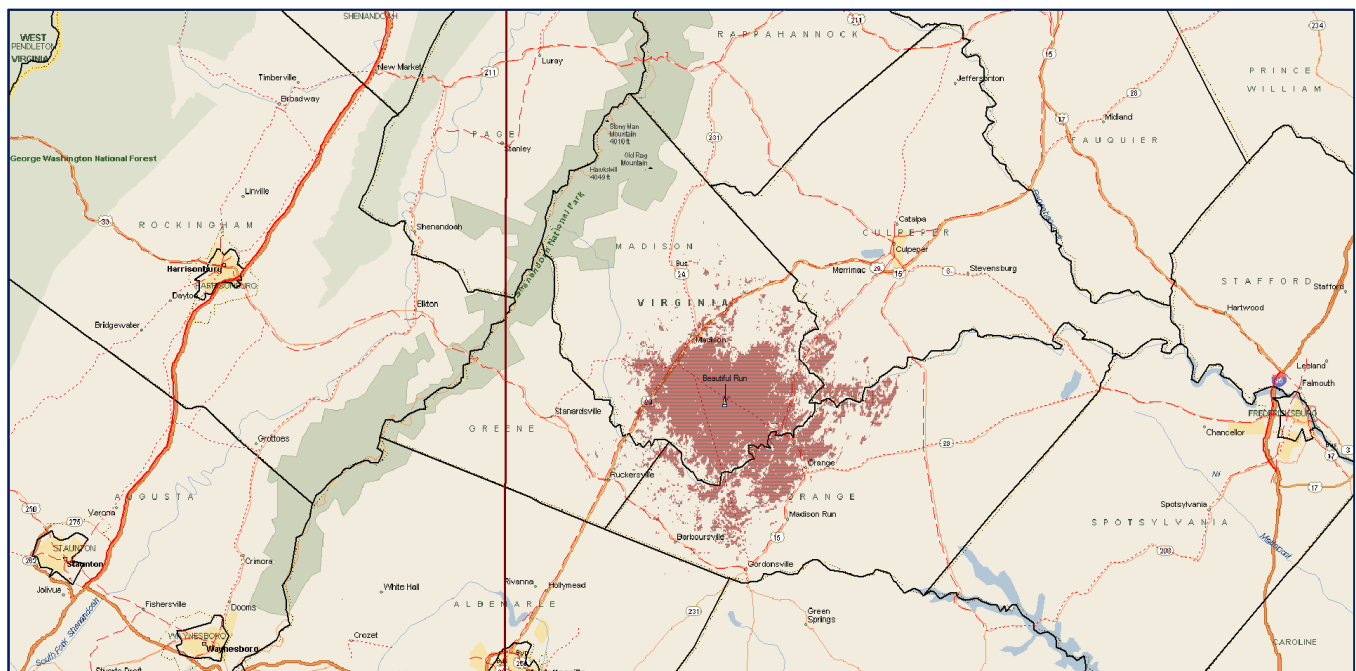


Figure 27: Portable On-Hip Indoor Coverage - 6 dB Building - Outbound - Beautiful Run

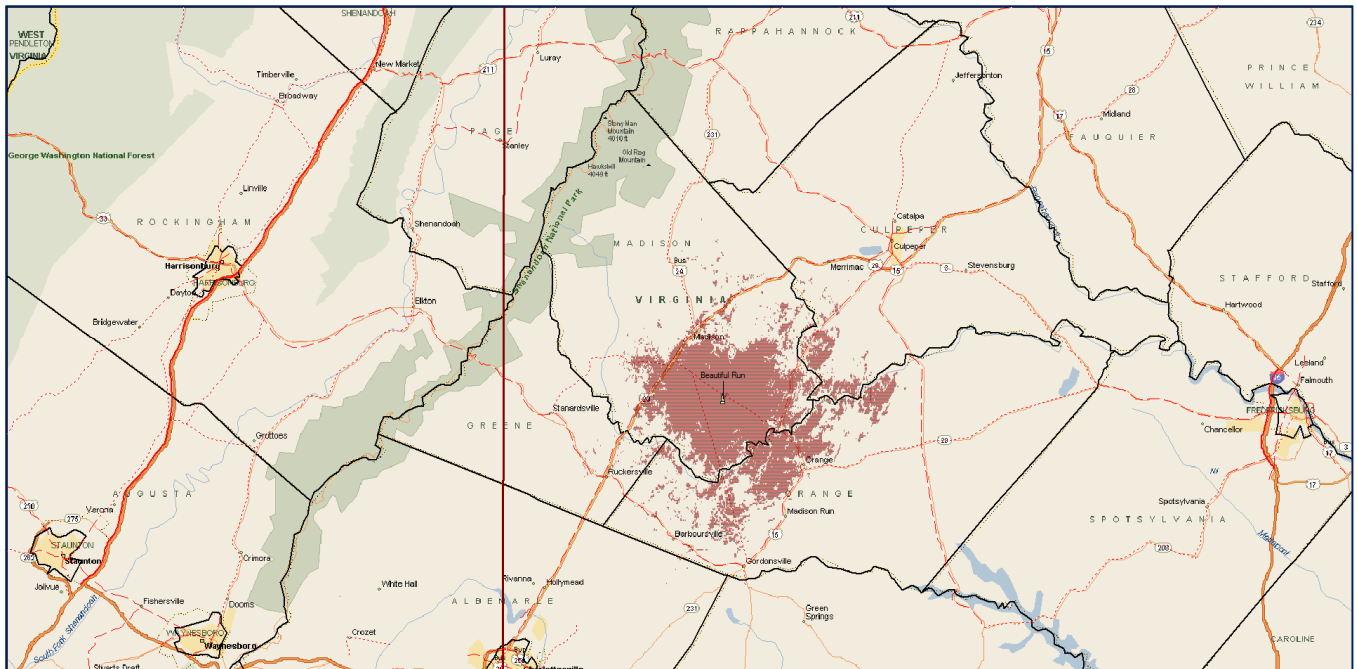


Figure 28: Portable On-Hip Indoor Coverage - 6 dB Building - Inbound - Beautiful Run

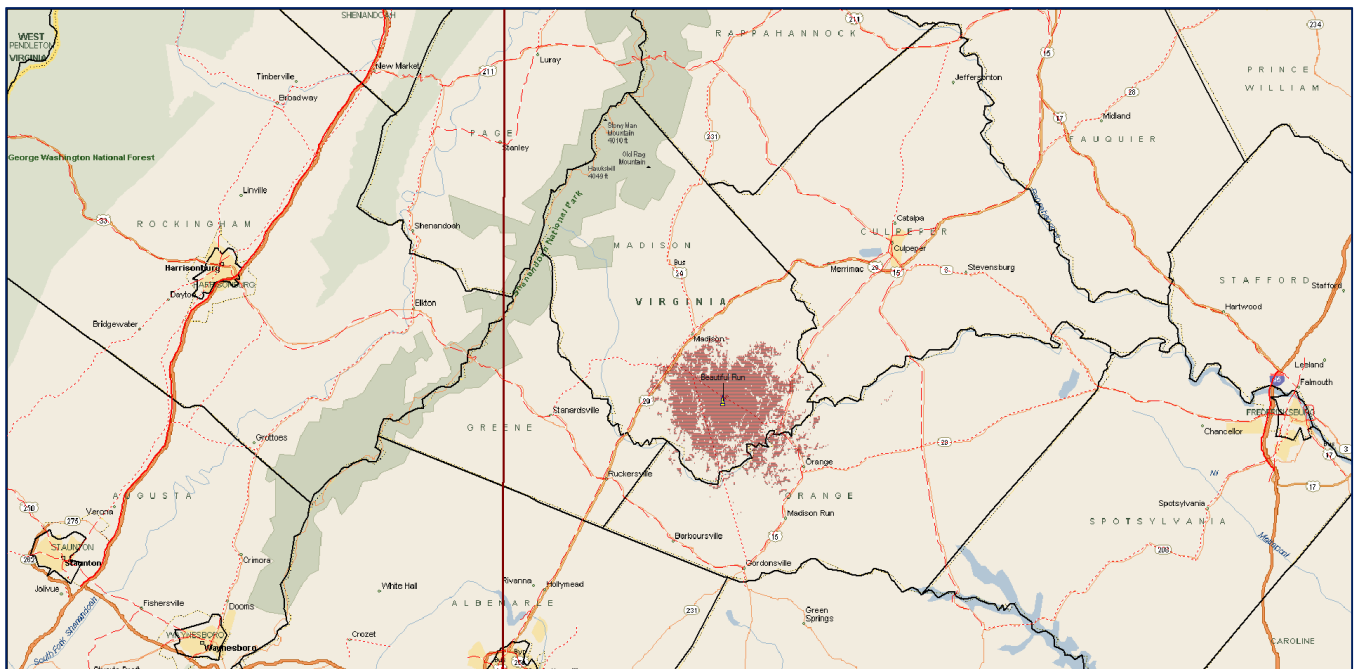


Figure 29: Portable On-Hip Indoor Coverage - 12 dB Building - Outbound - Beautiful Run

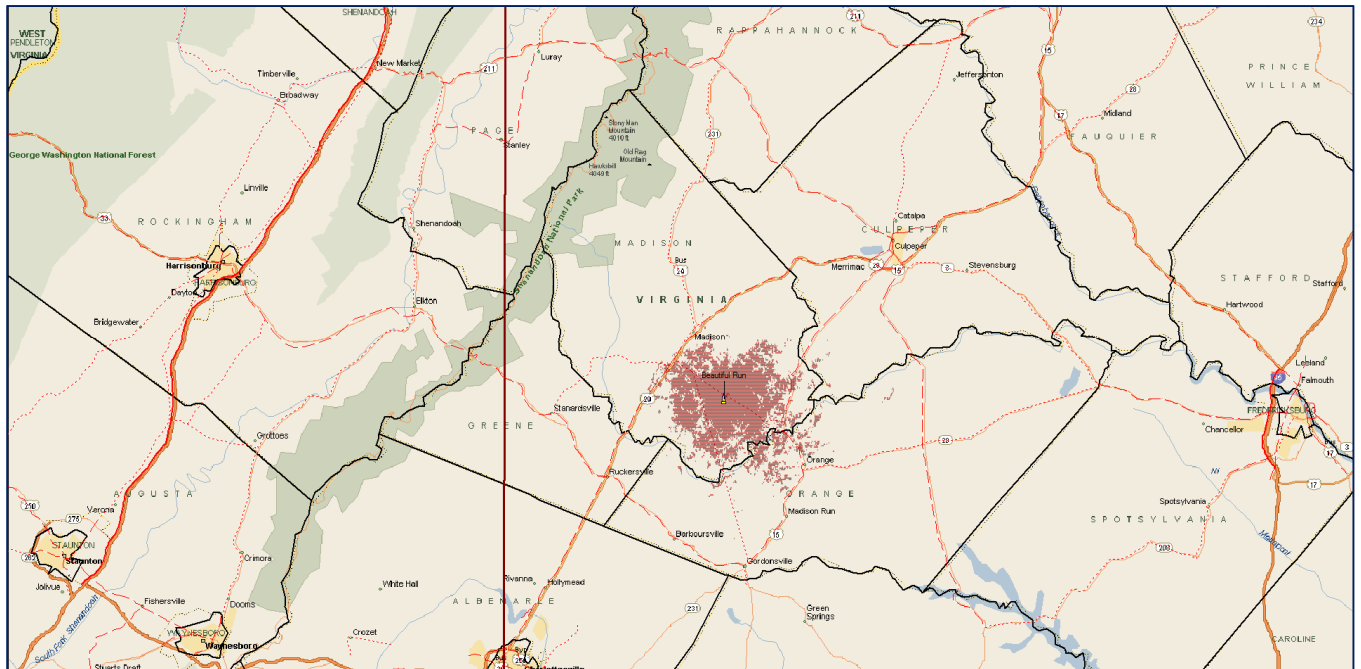


Figure 30: Portable On-Hip Indoor Coverage - 12 dB Building - Inbound - Beautiful Run

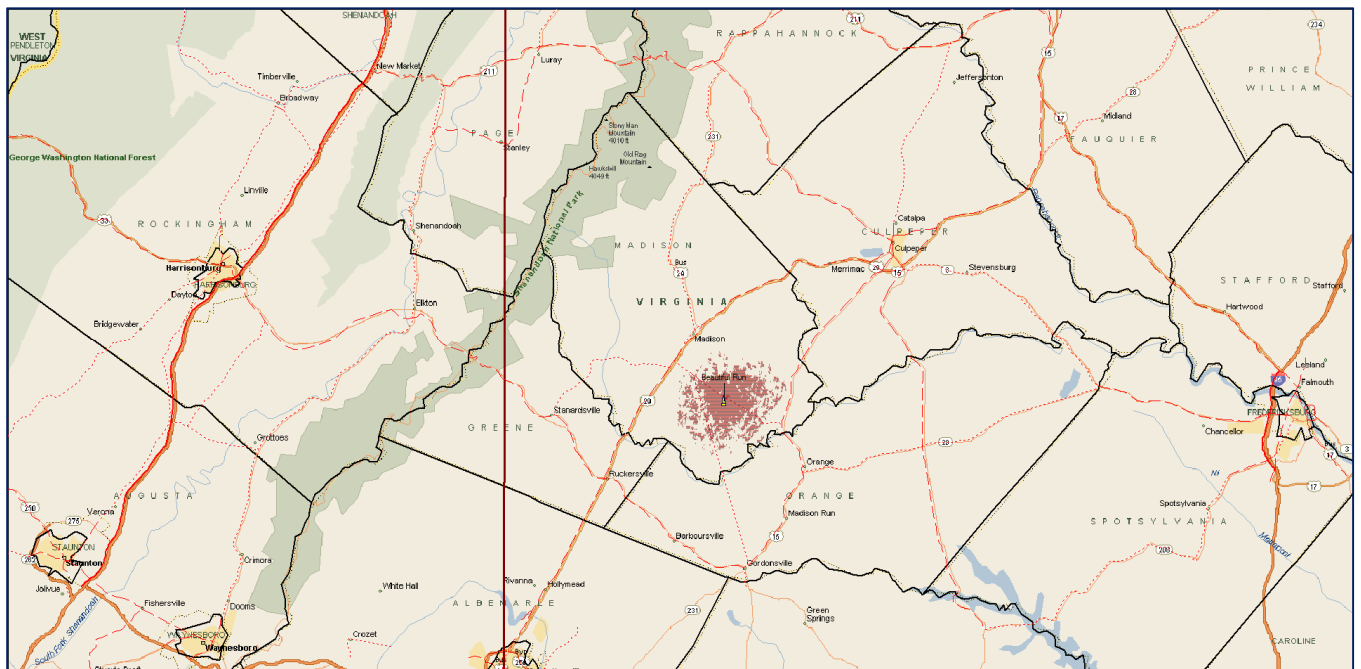


Figure 31: Portable On-Hip Indoor Coverage - 20 dB Building - Outbound - Beautiful Run

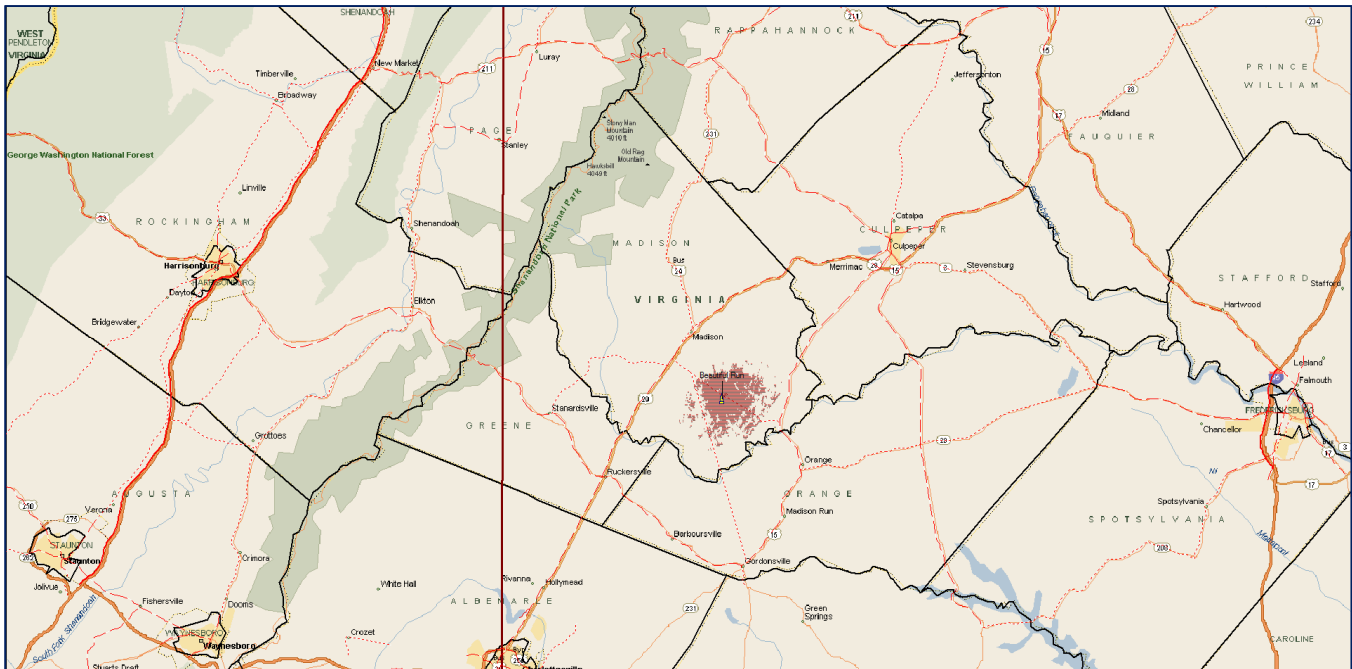
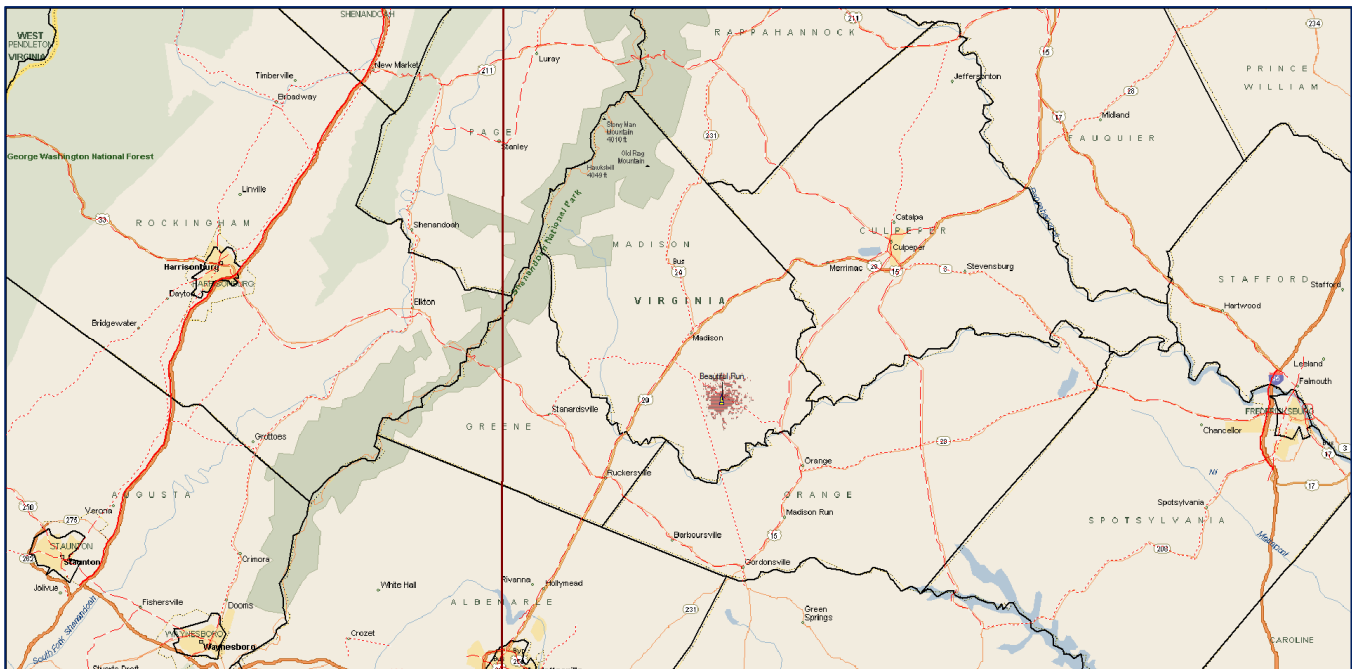


Figure 32: Portable On-Hip Indoor Coverage - 20 dB Building - Inbound - Beautiful Run



## APPENDIX C: ALTERNATIVE 1 - P25 PHASE 2 TRUNKED SYSTEM RADIO COVERAGE

### P25, Phase 2 Portable Radio –Received Signal Parameters - TDMA

Description	Outbound	Inbound	
	DAQ3.4	DAQ3.4	
5% BER Reference Sensitivity (from equipment spec sheets)	-119	-123	dBm
Static C/N (from TIA)	7.3	9	dB
Faded C/(I+N) (from TIA)	16.4	18.7	dB
Effective Faded Received Sensitivity	-109.9	-113.3	dBm
Additional Noise Degradation	3.0	3.0	dB
Net Faded Received Sensitivity	-106.7	-110.3	dBm



Figure 33: Mobile Coverage - Outbound - P25

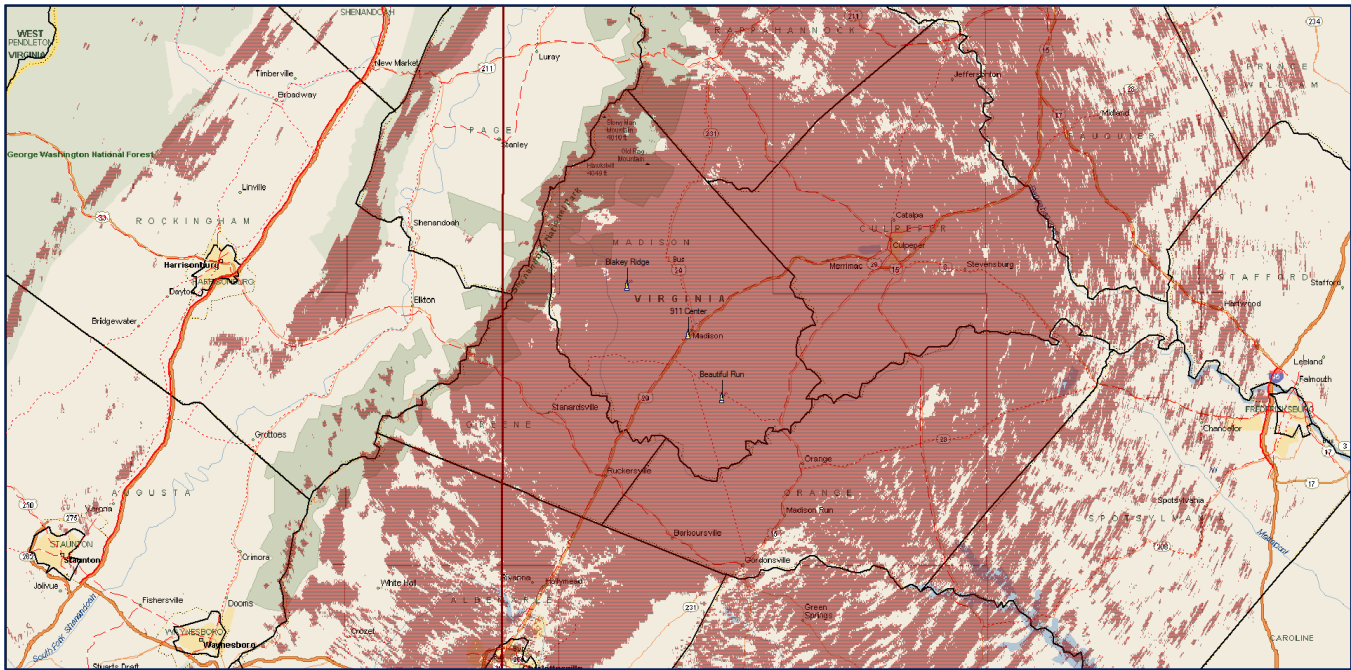


Figure 34: Mobile Coverage - Inbound - P25

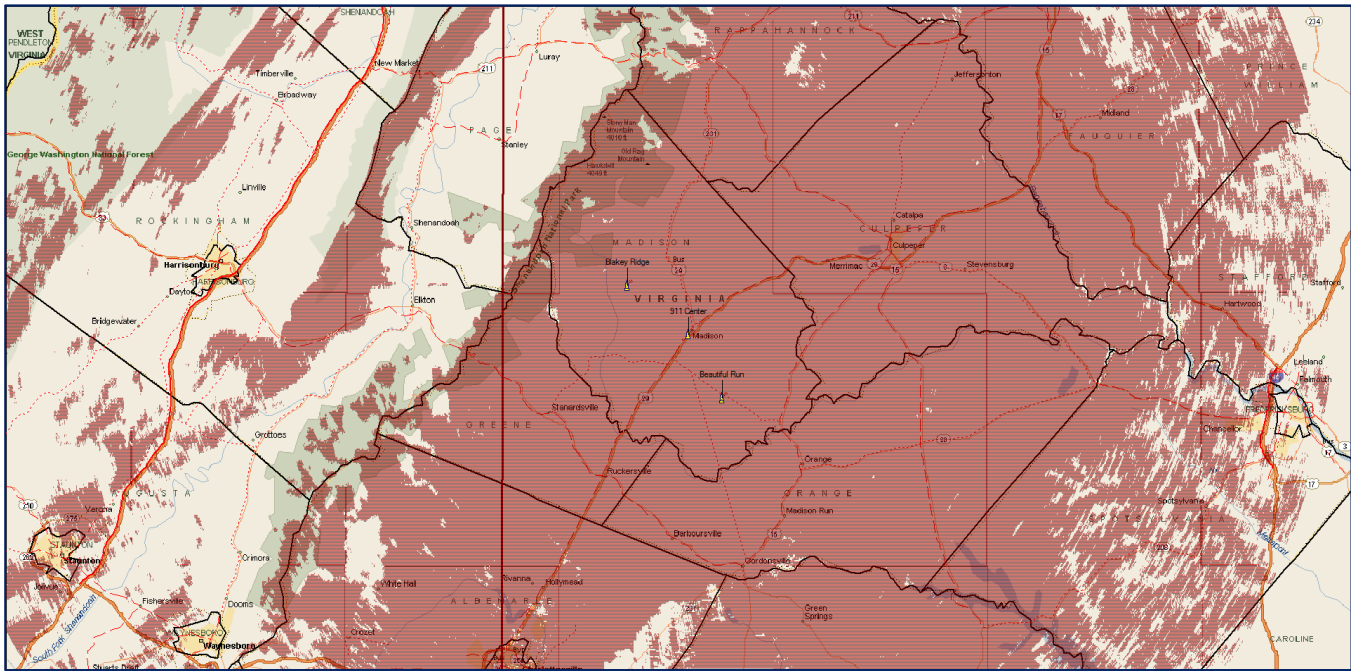


Figure 35: Portable On-Hip Outdoor Coverage - Outbound - P25

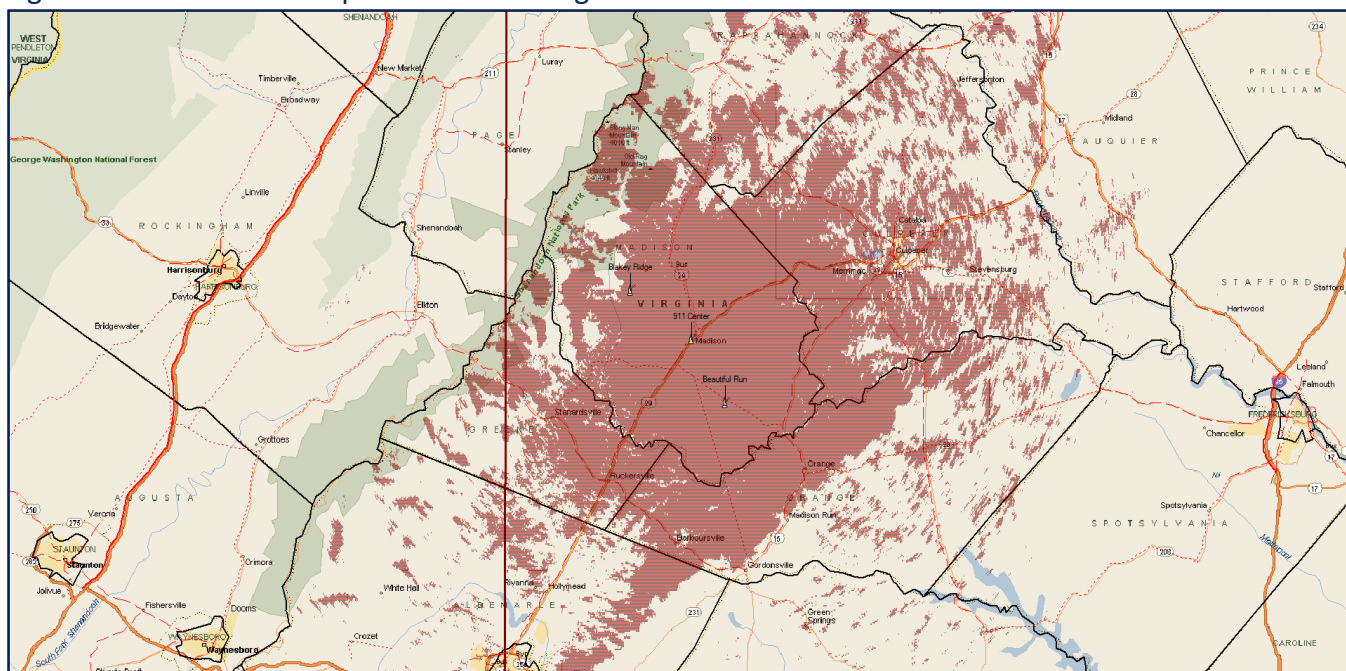


Figure 36: Portable On-Hip Outdoor Coverage - Inbound - P25

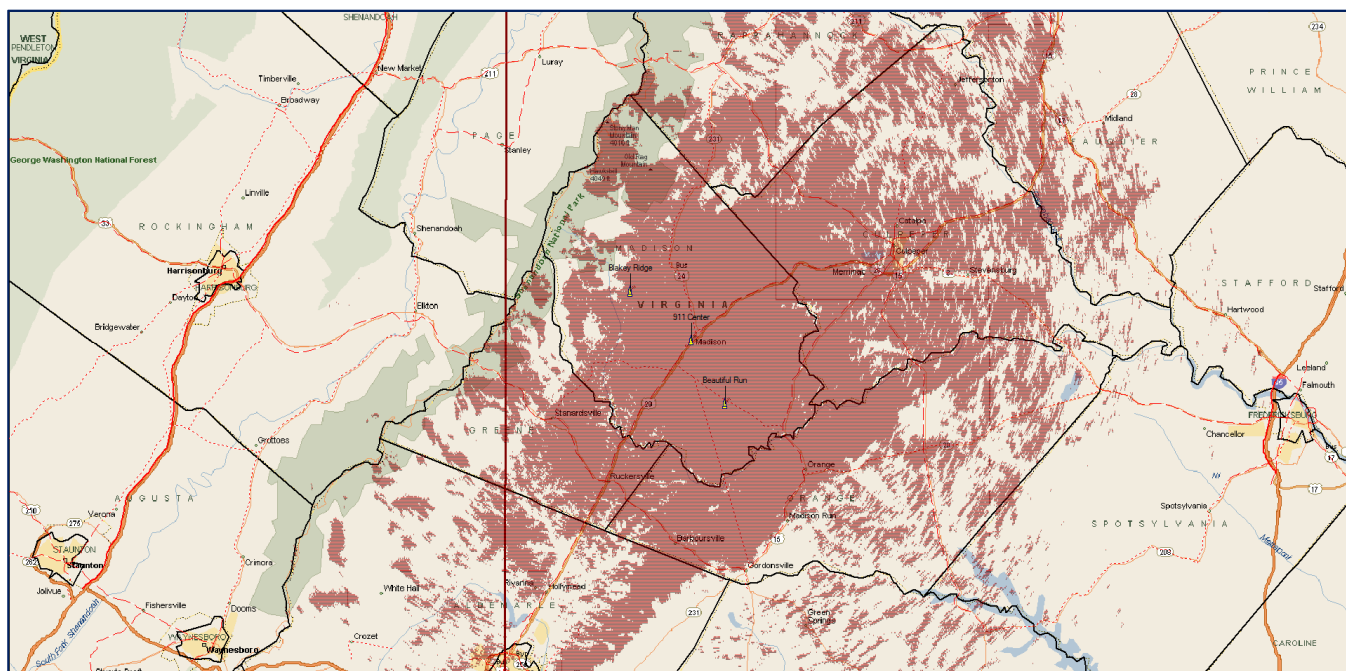




Figure 37: Portable On-Hip Indoor Coverage - 6dB - Outbound - P25

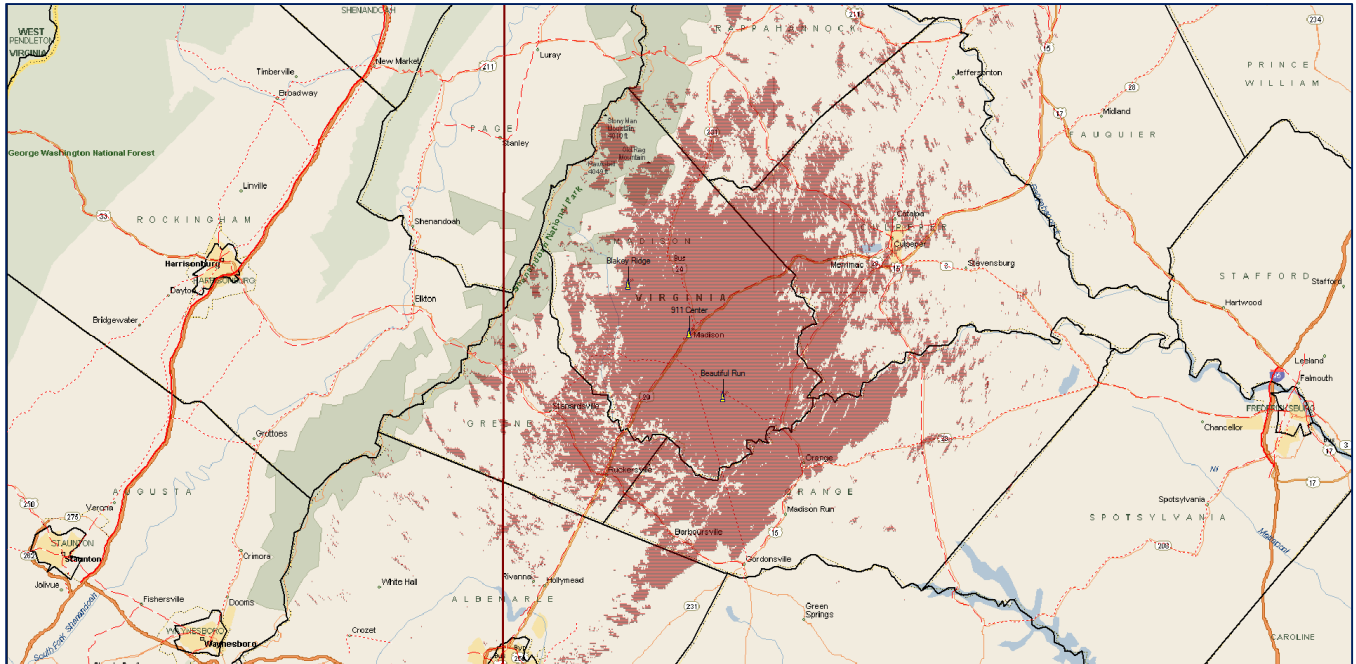


Figure 38: Portable On-Hip Indoor Coverage - 6dB Building - Inbound - P25

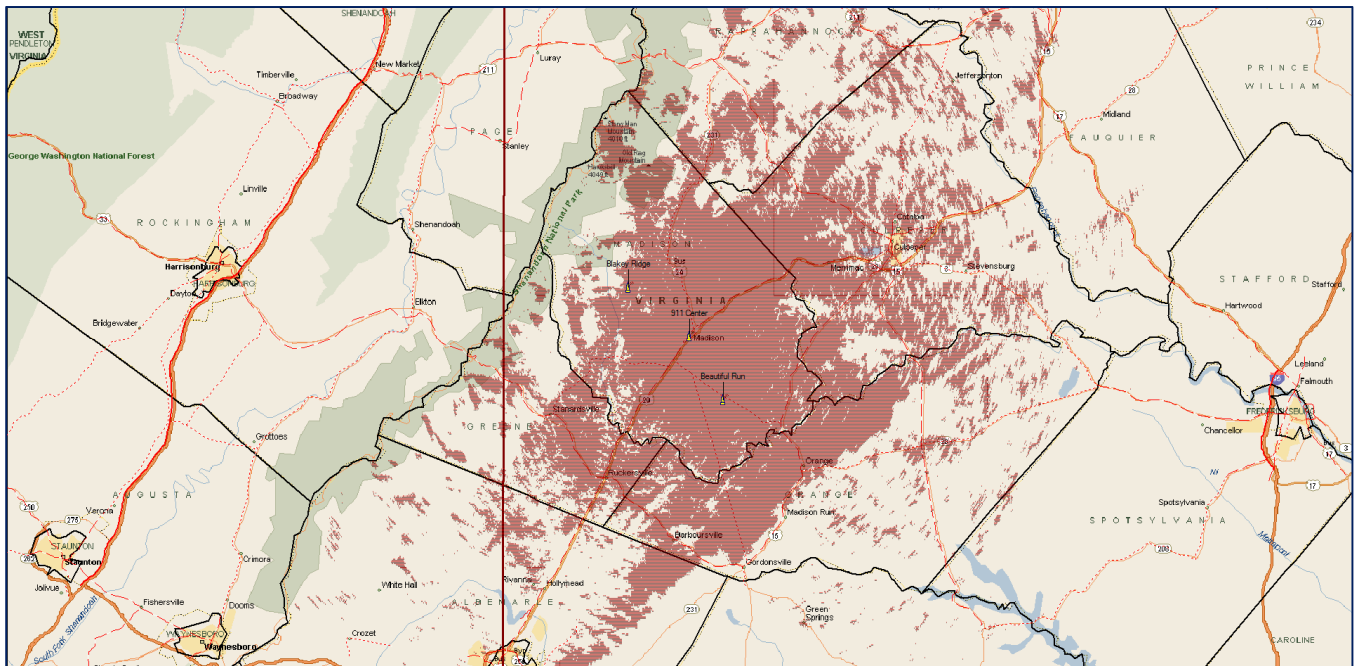


Figure 39: Portable On-Hip Indoor Coverage - 12 dB Building - Outbound - P25

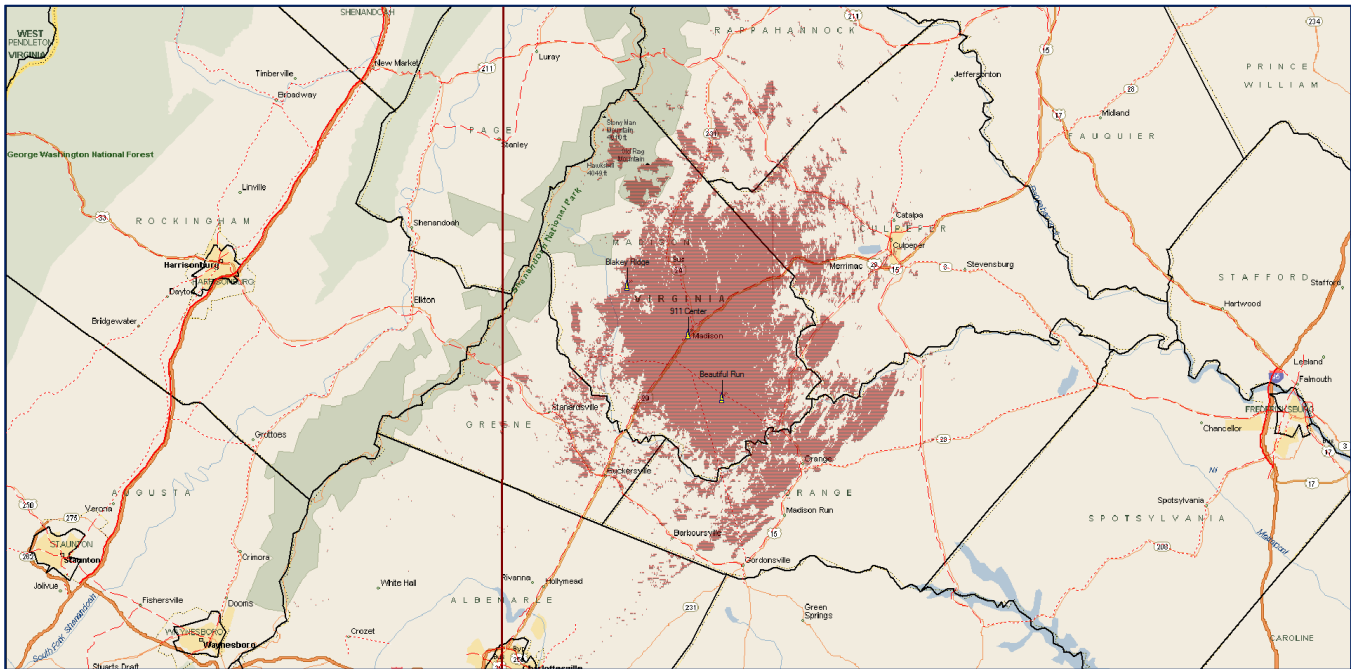


Figure 40: Portable On-Hip Indoor Coverage - 12 dB Building - Inbound - P25

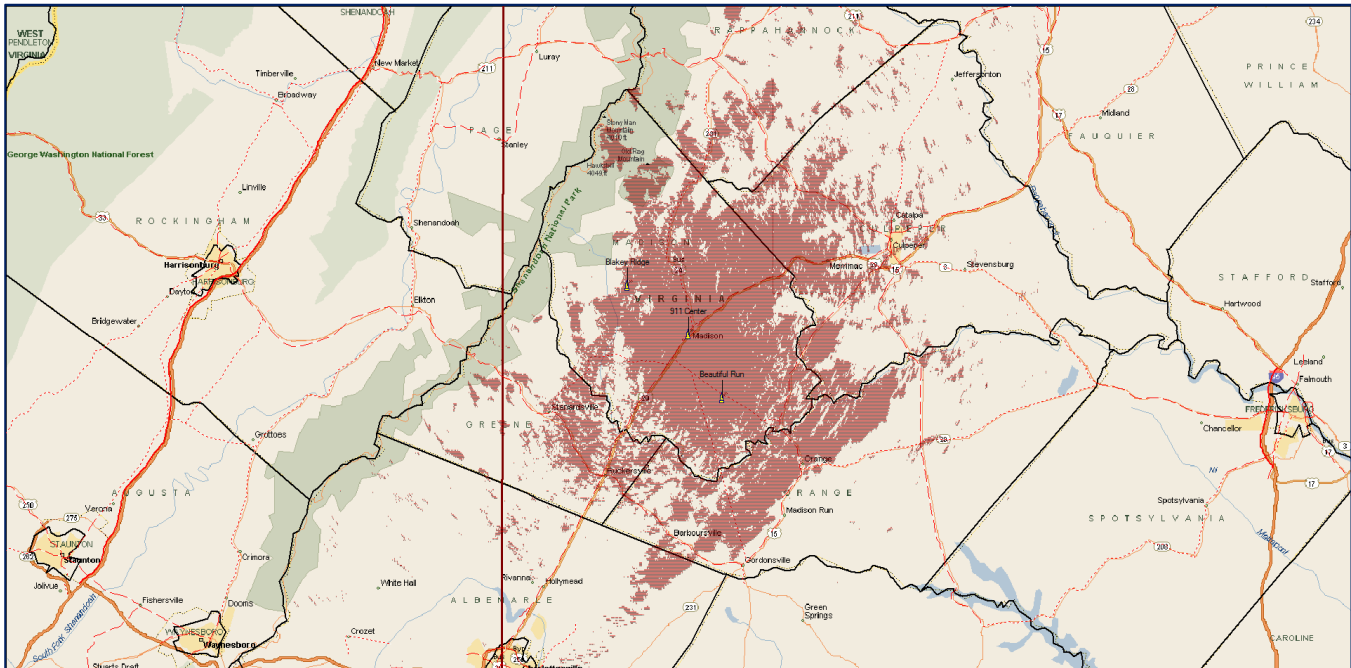


Figure 41: Portable On-Hip Indoor Coverage - 20 dB Building - Outbound - P25

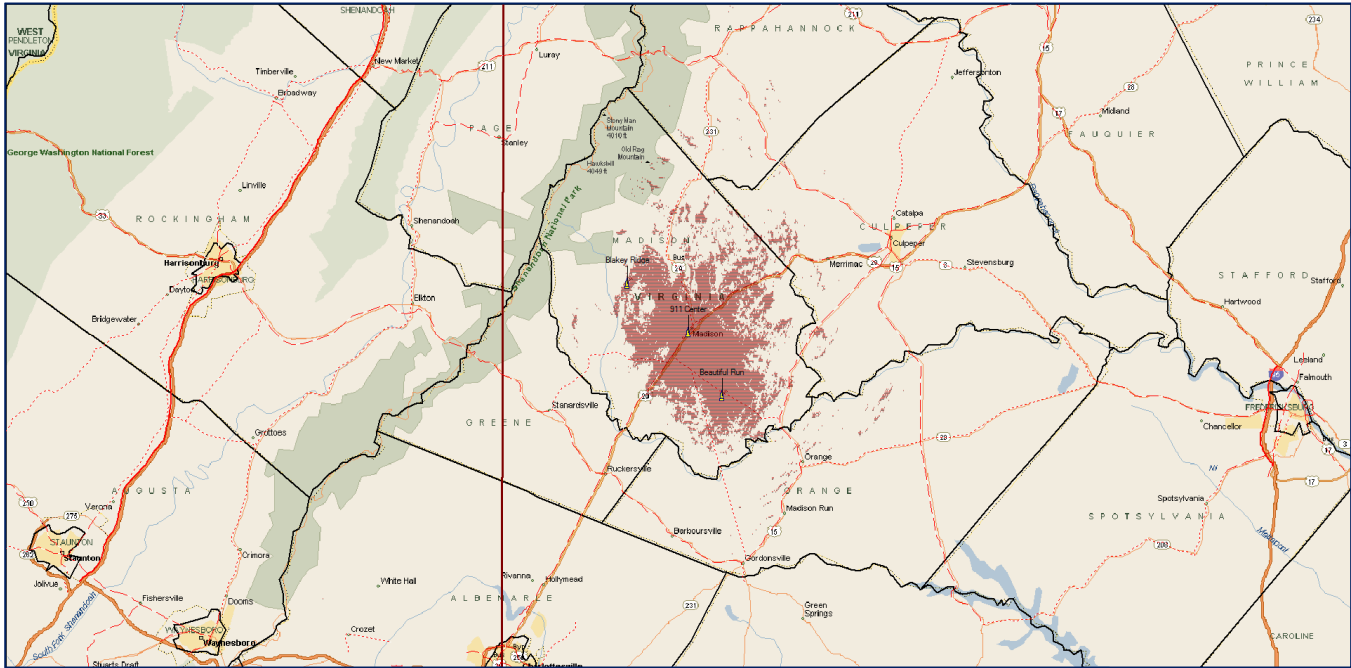
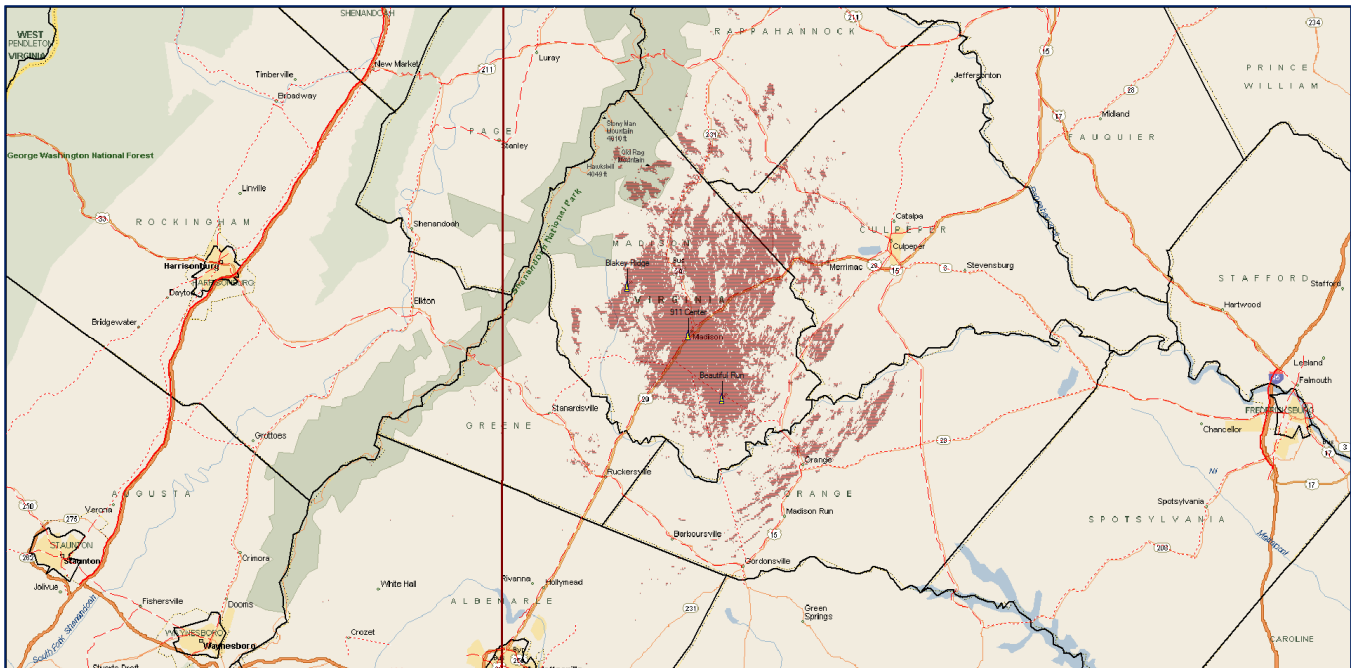


Figure 42: Portable On-Hip Indoor Coverage - 20 dB Building - Inbound - P25



## APPENDIX D: ALTERNATIVE 2 - P25 PHASE 2 TRUNKED SYSTEM RADIO COVERAGE - 6 SITES (3 GREENE, 3 MADISON)

### P25, Phase 2 Portable Radio –Received Signal Parameters – TDMA

Description	Outbound	Inbound	
	DAQ3.4	DAQ3.4	
5% BER Reference Sensitivity (from equipment spec sheets)	-119	-123	dBm
Static C/N (from TIA)	7.3	9	dB
Faded C/(I+N) (from TIA)	16.4	18.7	dB
Effective Faded Received Sensitivity	-109.9	-113.3	dBm
Additional Noise Degradation	3.0	3.0	dB
Net Faded Received Sensitivity	-106.7	-110.3	dBm



Figure 43: Mobile Coverage - Outbound - P25

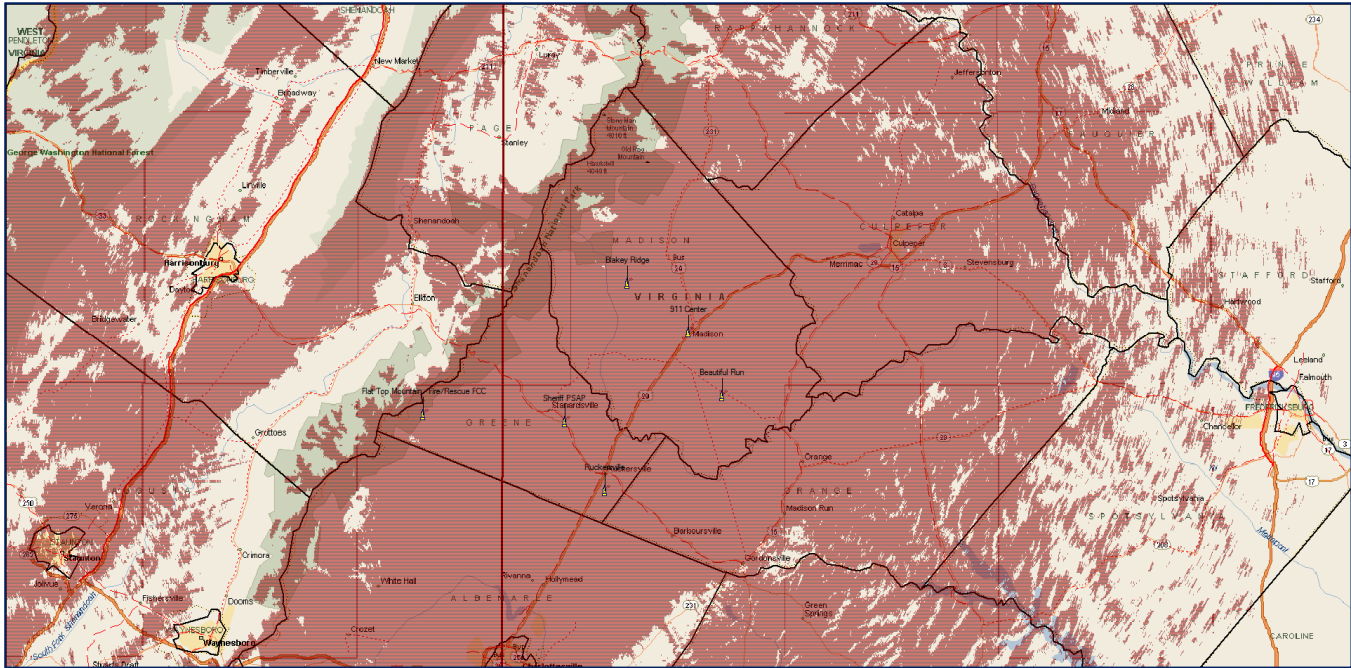


Figure 44: Mobile Coverage - Inbound - P25

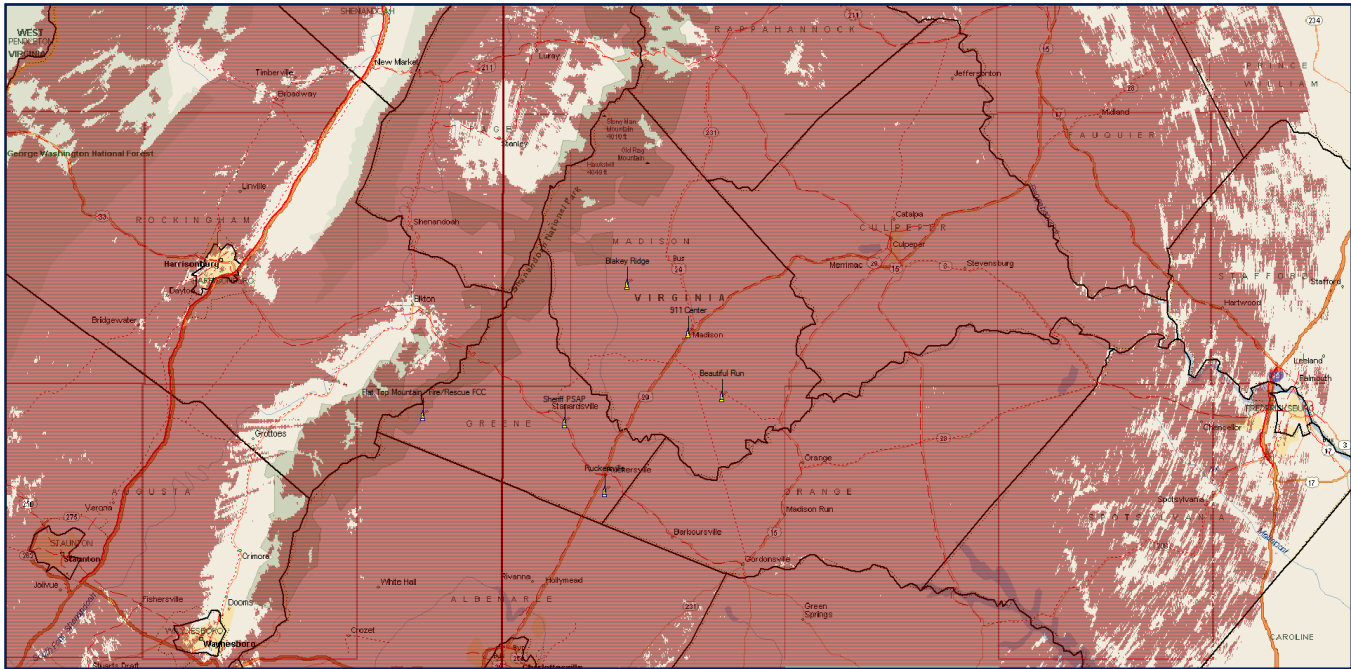


Figure 45: Portable On-Hip Outdoor Coverage - Outbound - P25

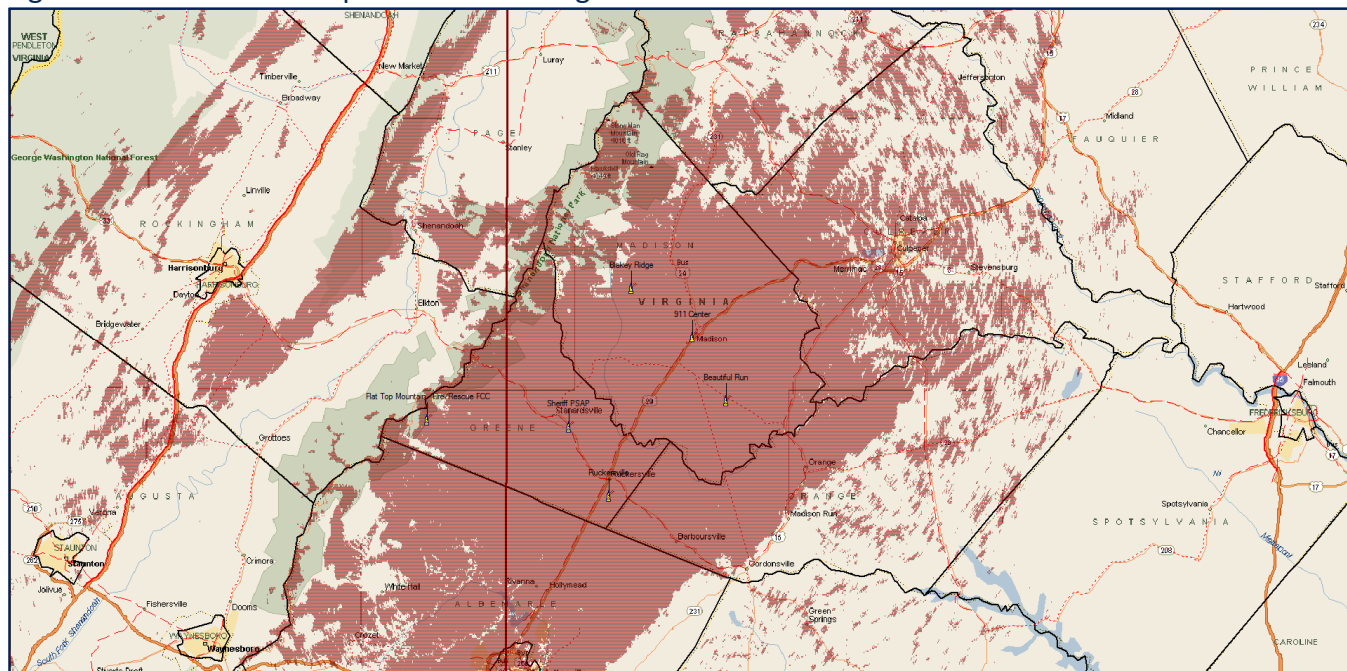


Figure 46: Portable On-Hip Outdoor Coverage - Inbound - P25

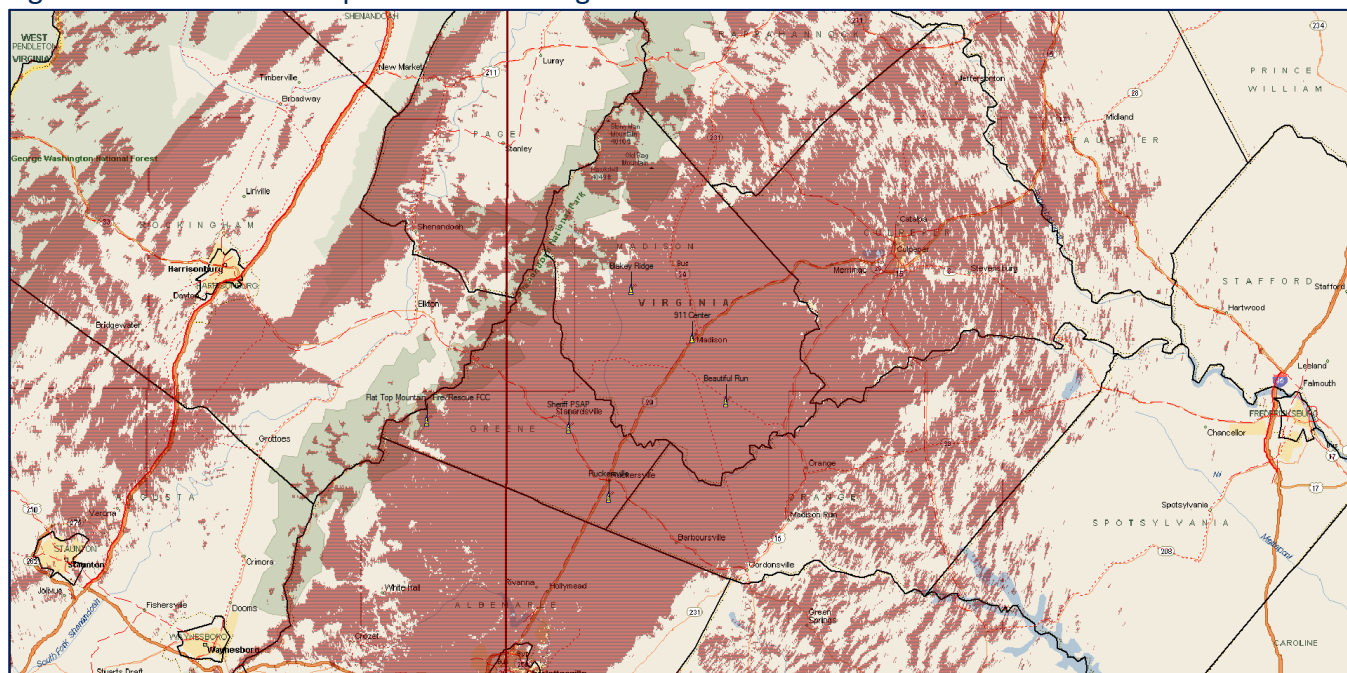




Figure 47: Portable On-Hip Indoor Coverage - 6 dB - Outbound - P25

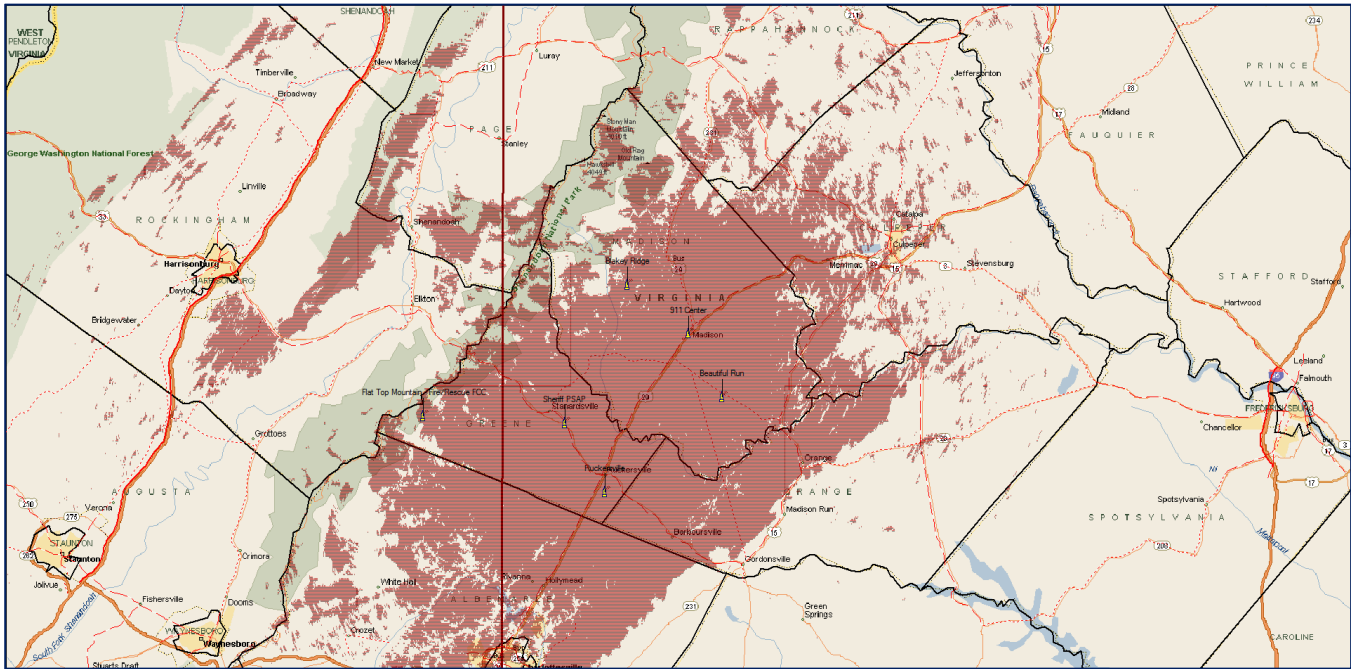


Figure 48: Portable On-Hip Indoor Coverage - 6 dB Building - Inbound - P25

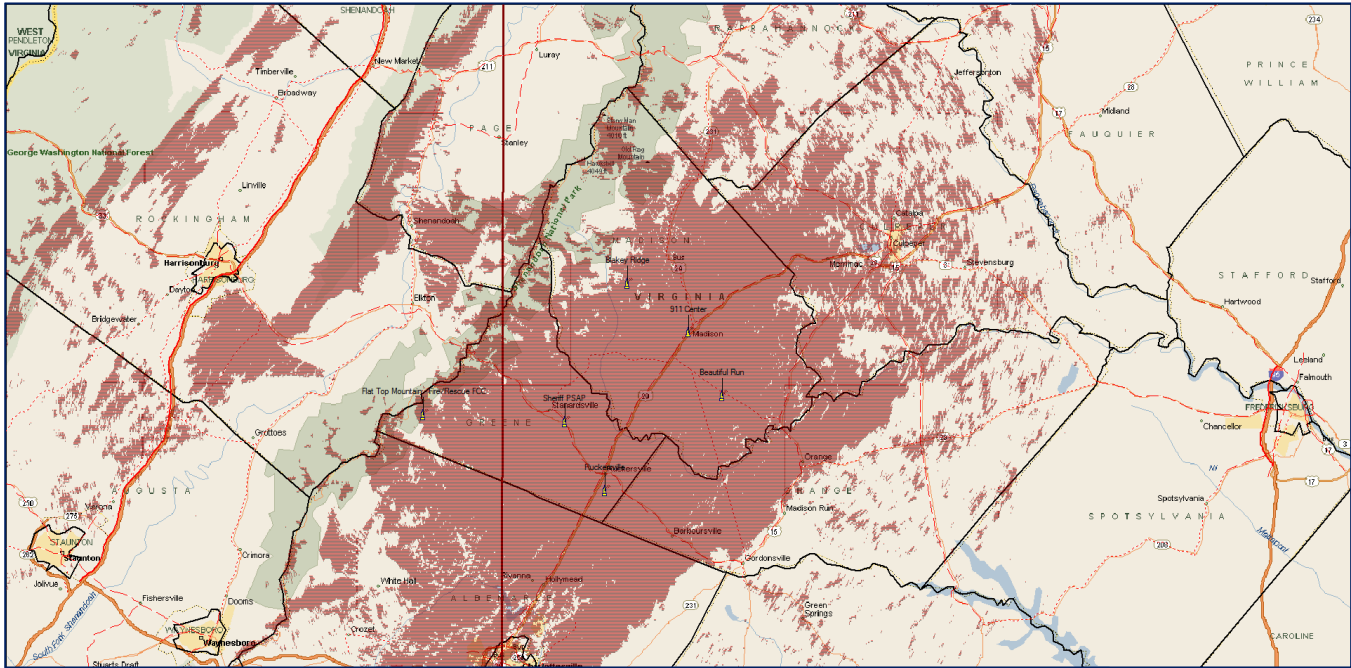




Figure 49: Portable On-Hip Indoor Coverage - 12 dB Building - Outbound - P25

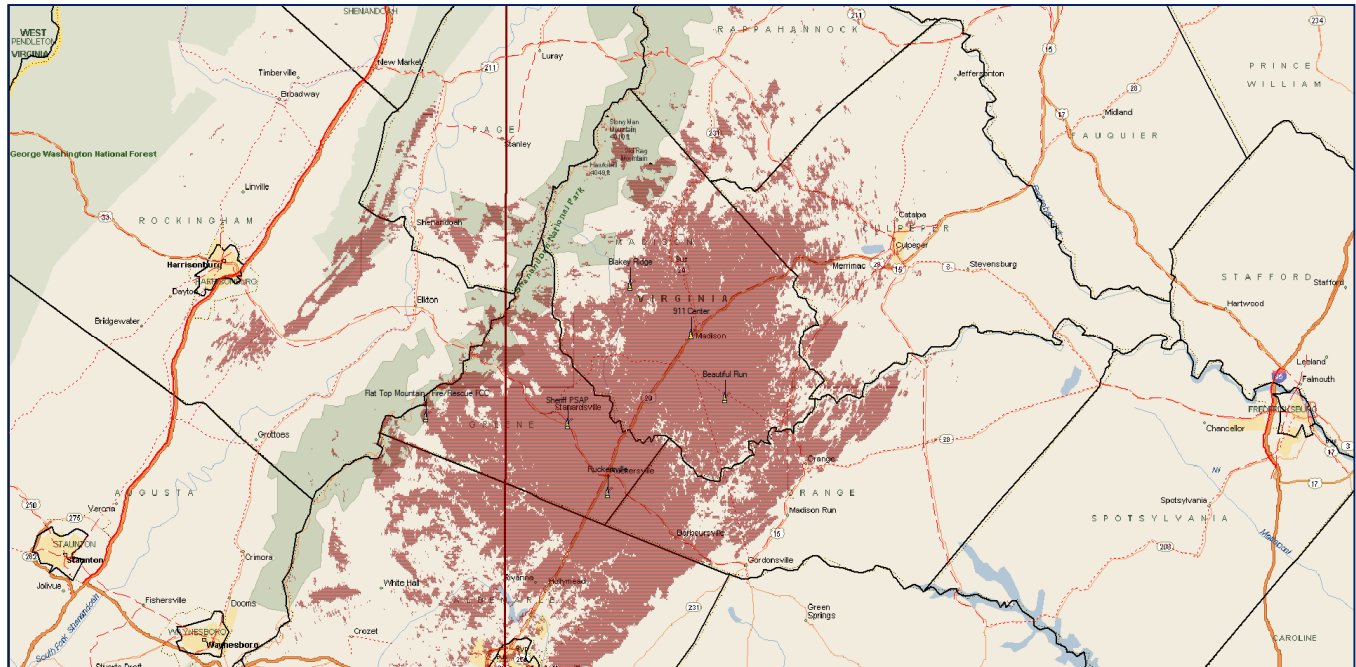


Figure 50: Portable On-Hip Indoor Coverage - 12 dB Building - Inbound - P25

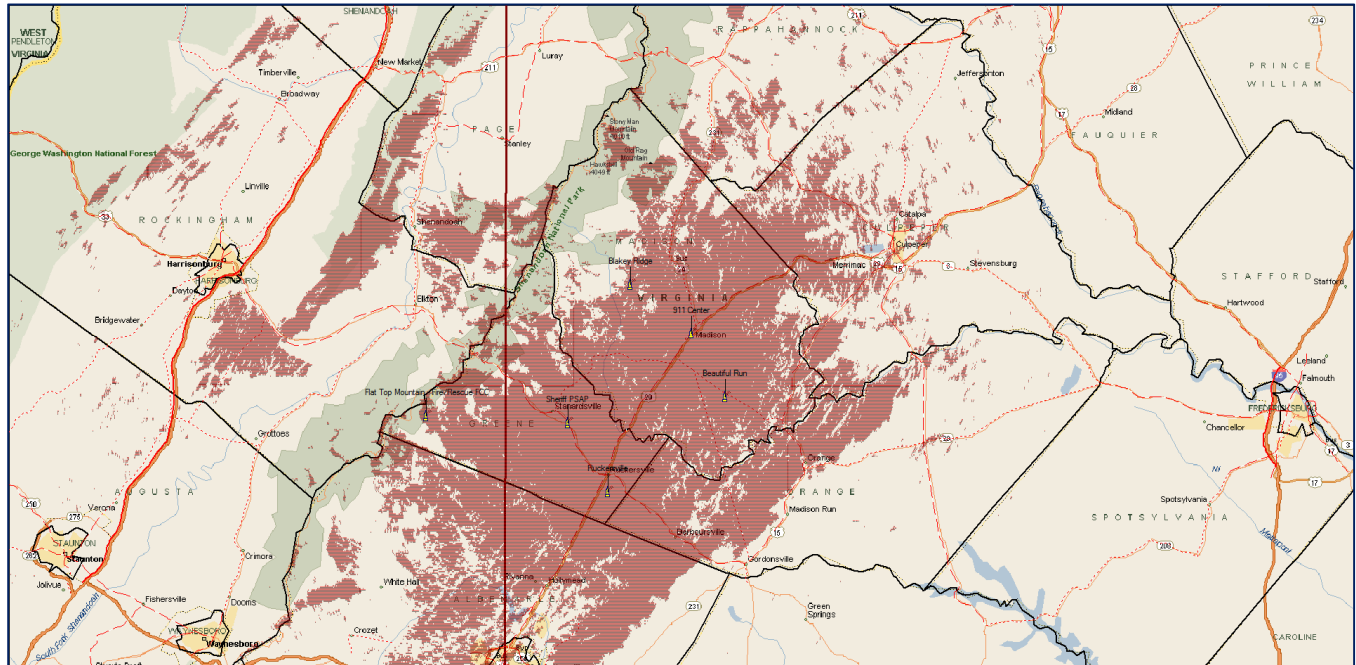


Figure 51: Portable On-Hip Indoor Coverage - 20 dB Building - Outbound - P25

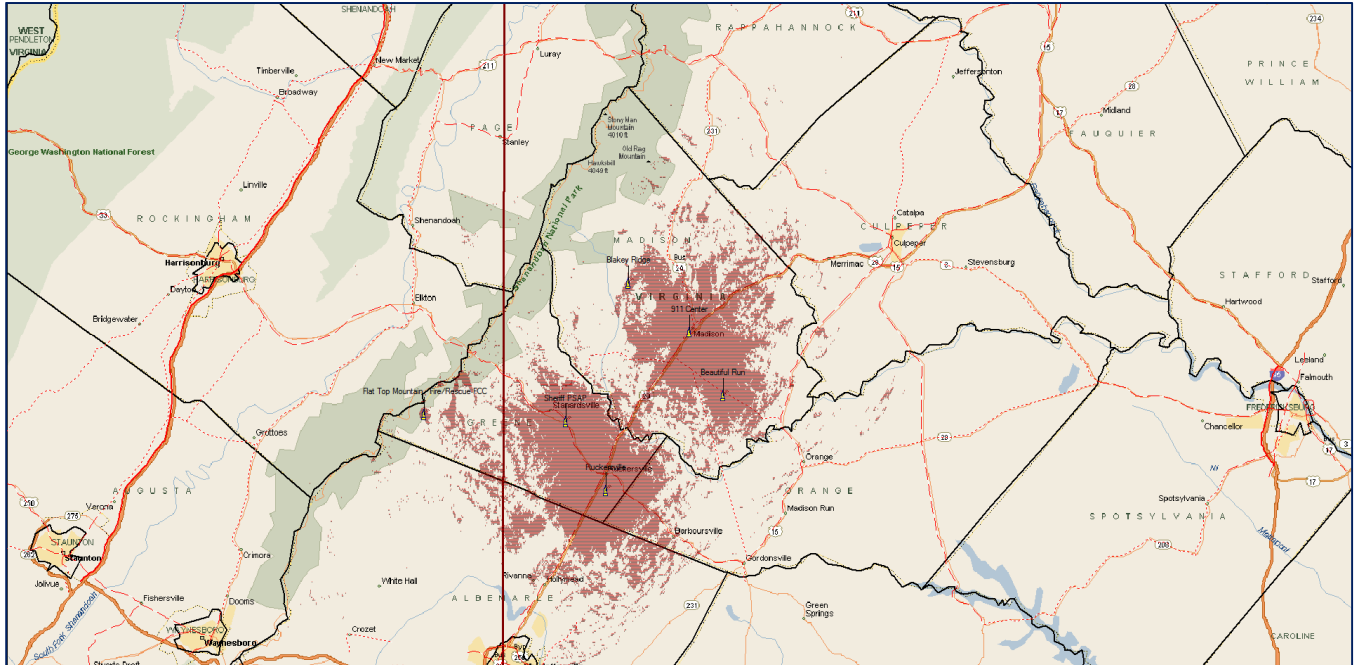


Figure 52: Portable On-Hip Indoor Coverage - 20 dB Building - Inbound - P25

